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Point of Care Anemia Device



Outline

- Background
- Product Design Specifications
- Past Work
- Alternative Designs
- Final Design
- Future Work



What is Anemia?

- Deficiency of hemoglobin in the blood, usually characterized by size and reduced number of red blood cells
- Three types:
 - Microcytic
 - Normocytic
 - Macrocytic
- Very common in underdeveloped countries



Figure 1. Normal vs anemic levels of red blood cells¹

Problem Statement

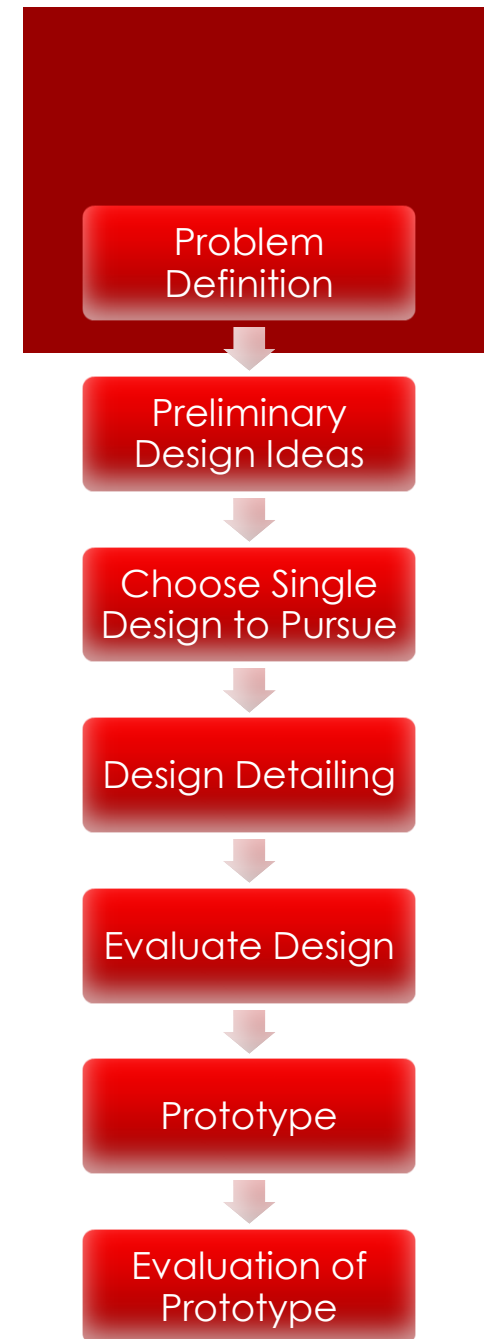


- Anemia is prevalent in developing countries
- Lack of funding and resources for complete blood count tests
- Client works with Global Brigades
- Design a cheap and accurate alternative for point of care anemia diagnosis



Product Design Specifications

- Accurately measure:
 - Mean corpuscular volume
 - Number of red blood cells
- Determine type of anemia
- Cost-effective
- Portable
- Easy-to-use
- Reusable
- Contained environment



Past Work

- Passive microfluidic device
- Measures differences in resistance
- Proof-of-concept: validated using microparticles

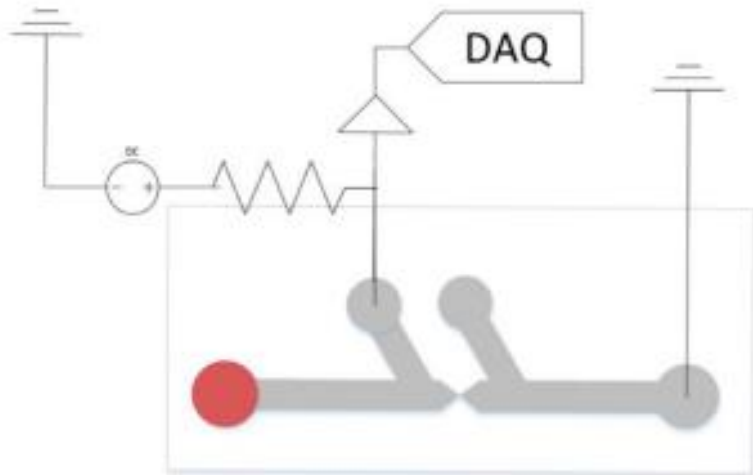


Figure 2. Measurement circuit schematic²

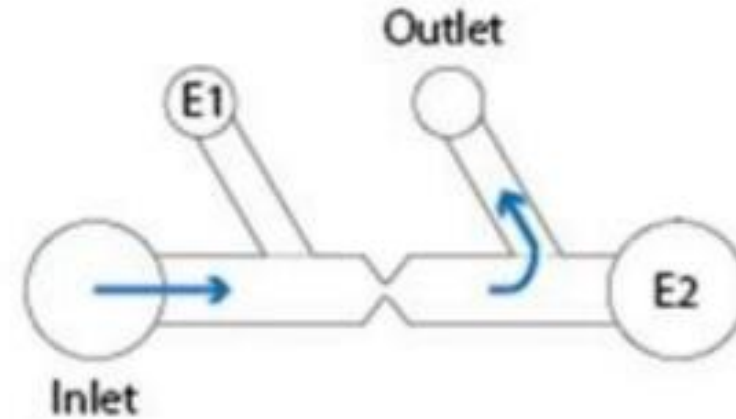


Figure 3. Channel Design²

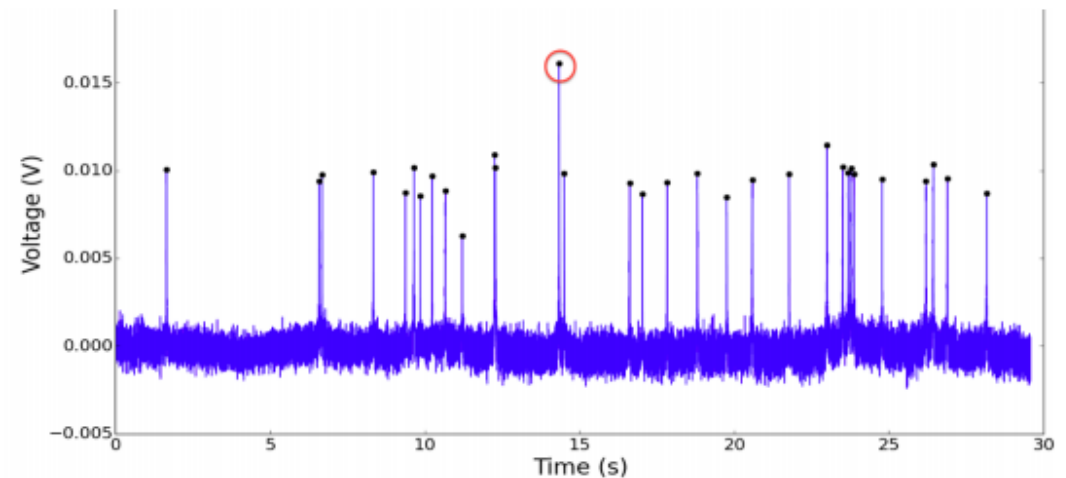


Figure 4. Voltage vs Time with coincident event²

Microfluidic pumping techniques:

Passive Pump

- Droplet placed on inlet allows particles to pass through channel
- Cells will flow down concentration gradient
 - Advantages:
 - Minimal materials
 - Low cost
 - Disadvantages:
 - Requires patience and skill
 - No control over flow

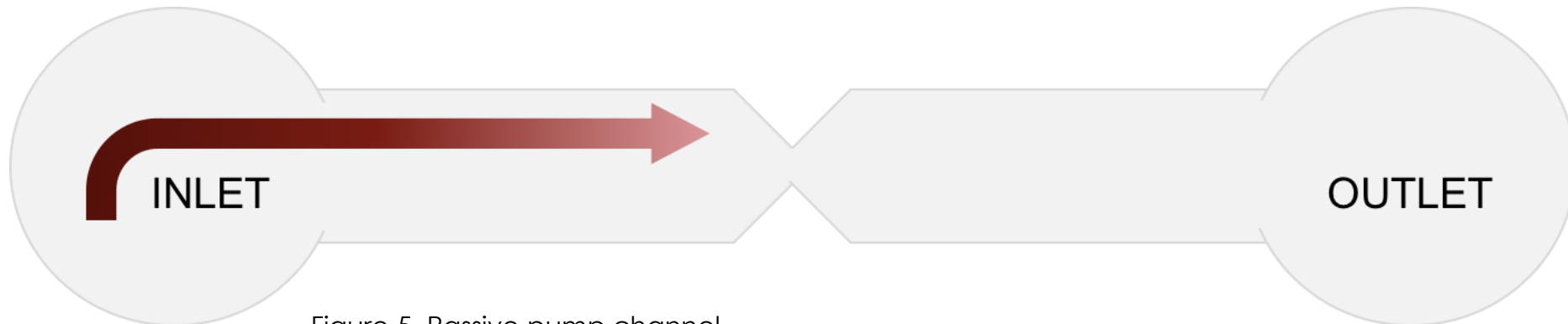


Figure 5. Passive pump channel

Microfluidic pumping techniques:

Syringe Pump



- Manually pass blood and fluid through channels with syringe
- Control flow rate based on syringe movement speed and diameter

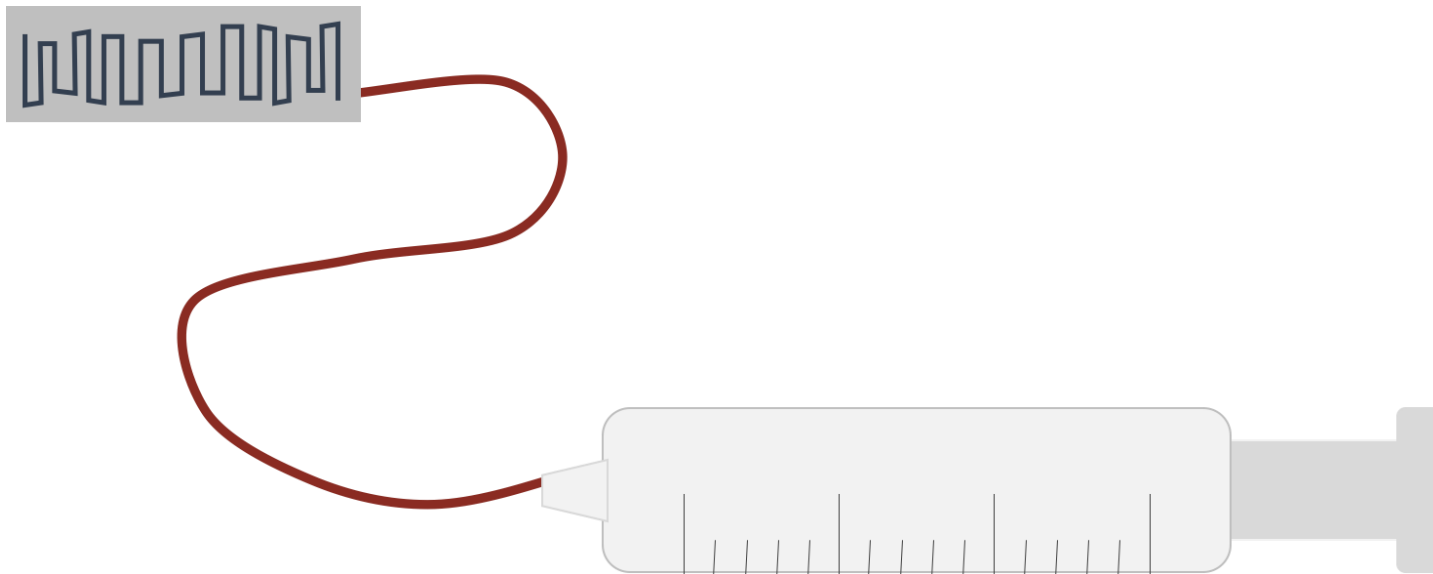


Figure 6. Syringe pump

- Advantages:
 - Easy and quick to operate
 - Easy to fabricate
- Disadvantages:
 - Flow rate dependent on user
 - Rate will vary each use

Microfluidic pumping techniques

Peristaltic Pump

- Blood and fluid loaded into flexible tubing
- Rotor compresses tubing sending blood through channels

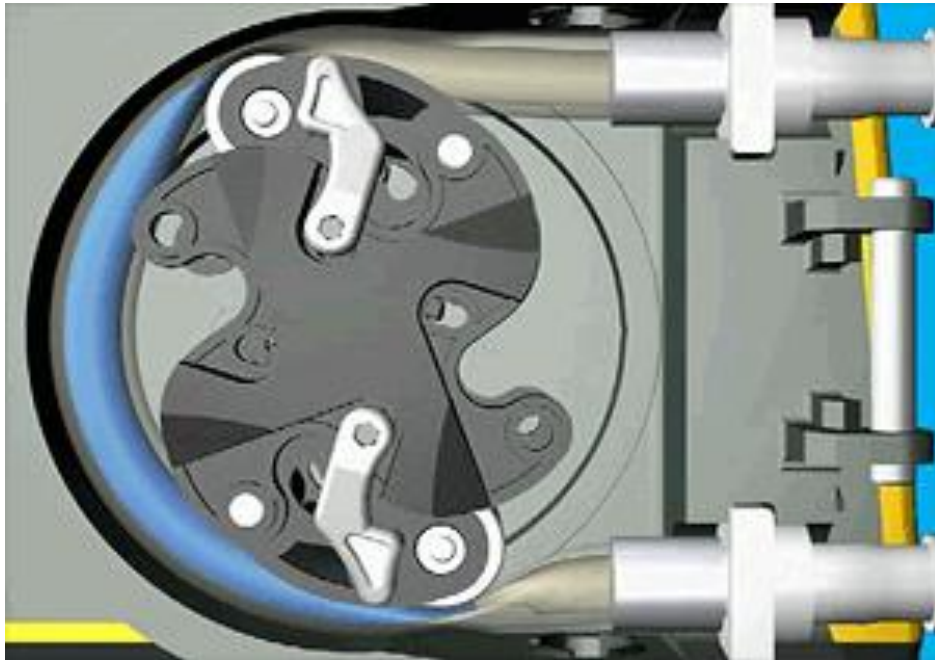


Figure 7. Peristaltic pump³

- Advantages:
 - Pumps blood automatically
 - Flow rate not user dependent
- Disadvantages:
 - Uneven pumping
 - Larger size
 - Many mechanical parts

Microfluidic Filtering techniques:

Cell Filter

- RBC diameter: 4-10 μm
- WBC diameter: 12-15 μm
- Polyethylene disposable filter funnel, pore size 10 μm
 - Advantages:
 - Easy to manufacture
 - Low operation time
 - Disadvantages:
 - Short lifespan since disposable



Figure 8. Syringe Filter⁴

Microfluidic Filtering techniques: **Cascading Filter**

- Multiple levels of filtering
- Blood travels through three filters of decreasing pore size
 - Advantages:
 - Decreases cell accumulation
 - Disadvantages:
 - Difficult to manufacture
 - Longer operation time

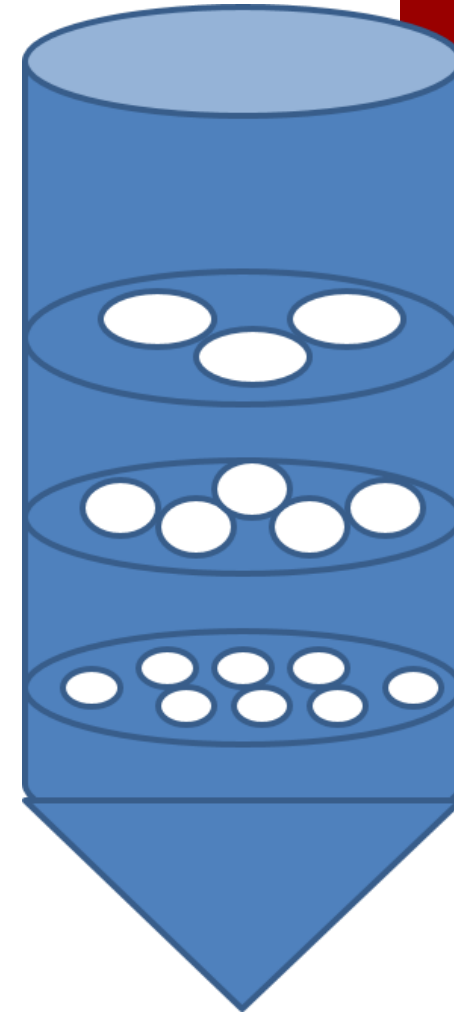
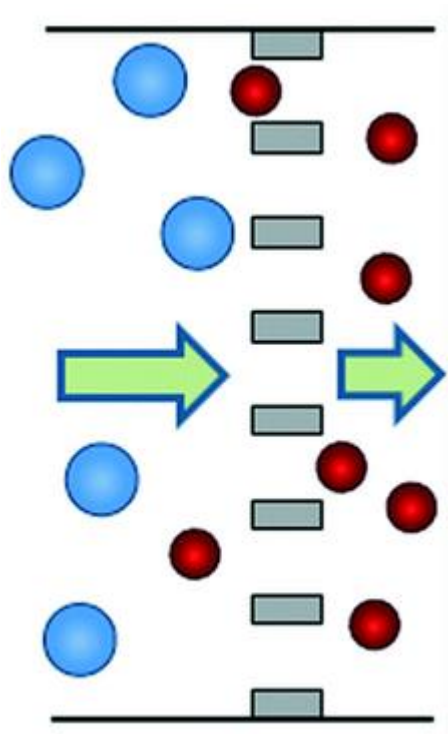


Figure 9. Cascading Filter

Microfluidic Filtering techniques:

Built-in Microfluidic Filter

- Blood flows through pillar wall with 11 μm openings



- Advantages:
 - Easy to use
 - Integrated into existing device
- Disadvantages:
 - Difficult to fabricate
 - White blood cells and debris clog easily

Figure 10. Pillar filtering⁵

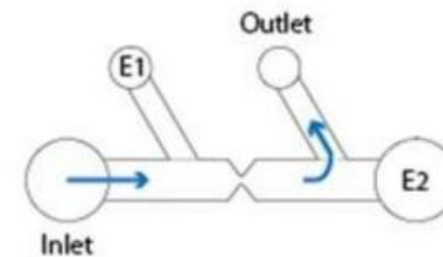
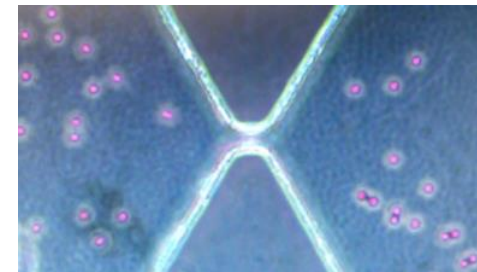
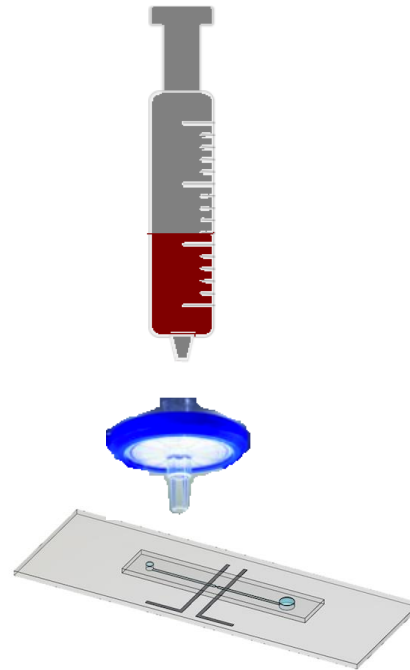
Pumping- Design Matrix

Design Criteria	Passive Pump		Syringe		Peristaltic Pump	
Ease of Use (25)	1/5	5	4/5	20	2/5	10
Time of Use (25)	1/5	5	3/5	15	3/5	15
Cost (20)	5/5	20	3/5	12	2/5	8
Ease of Manufacturing (15)	5/5	15	4/5	12	3/5	9
Size (10)	5/5	10	3/5	6	2/5	4
Safety (5)	5/5	5	5/5	5	5/5	5
Total (100)	60		70 		51	

Filtering - Design Matrix

Design Criteria	Cell Filter		Cascading Filter		Built-in Filter	
Ease of Use (25)	4/5	20	4/5	20	5/5	25
Time of Use (20)	3/5	12	2/5	8	4/5	16
Cost (20)	5/5	20	2/5	8	2/5	8
Ease of manufacturing (15)	5/5	15	3/5	9	1/5	3
Size (10)	4/5	8	3/5	6	5/5	10
Lifespan (5)	2/5	2	3/5	3	3/5	3
Safety (5)	5/5	5	5/5	5	5/5	5
Total (100)	82 ★		59		70	

Final Design



Blood Collection

Dilution

Filtration

Pump

Measure

Diagnosis

Future Work

- Microchannel designs/fabrication:
 - Micro milling
 - thin layer deposition methods

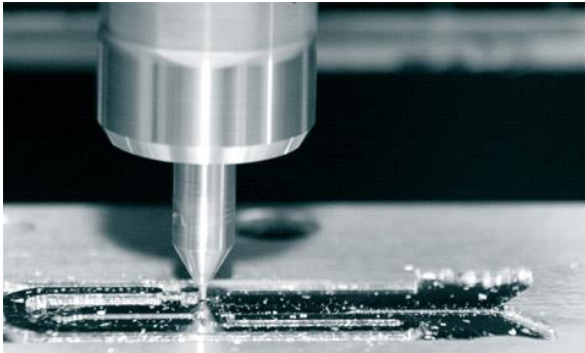


Figure 12. Micro milling⁶

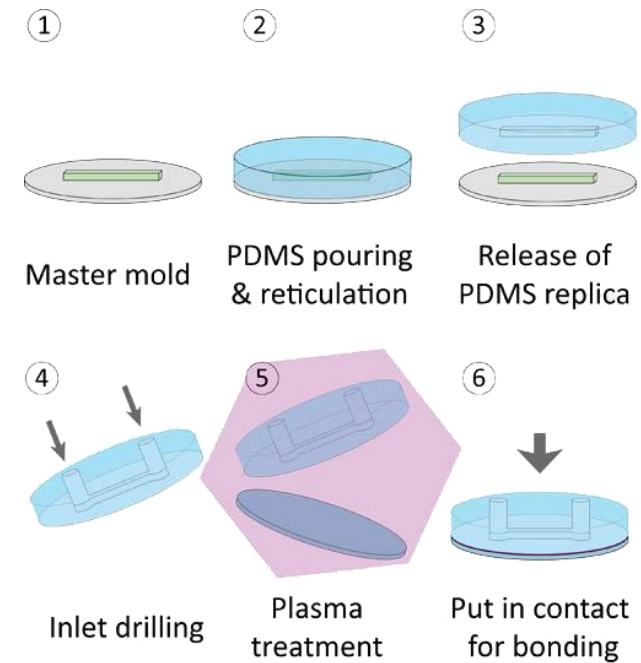


Figure 13. Thin layer deposition⁷

Future Work

- Integrating improvements into current device
 - filtering techniques (cell filter)
 - pumping methods (syringe)



Figure 14. Automated syringe pump⁸

Future Work

- Testing:
 - Proof of concept
 - Blood tests:
 - Animal models
 - Human blood samples



Figure 14. Micro beads ⁹



Figure 15. Blood collection¹⁰



Acknowledgements

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+Jolene Enge

+Michelle Chiang

+Russell Little

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×Our advisor Dr. Thomas Yen

×Our client Dr. Philip Bain

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