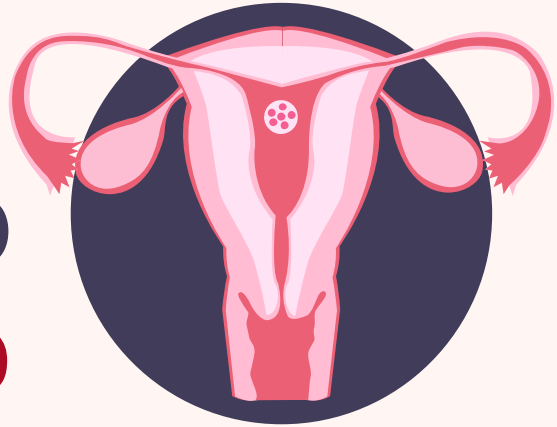
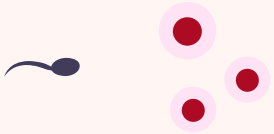
Uterus-on-a-Chip Model for In-Vitro Fertilization



Riya, Elena, Amanda, Kiran

Outline



01 **Background**

Traditional in-vitro fertilization techniques

02 **EVATAR**

What current similar technologies have been created?

03 **Construction**

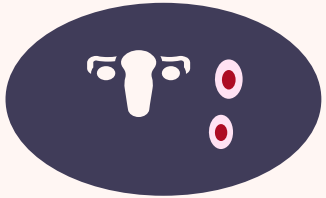
Our proposed design and its key features

04 **Improvements**

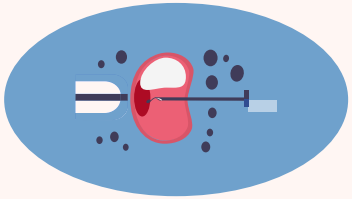
What are the limitations? How could this chip be improved? What are the ethical considerations of making such a device?

In Vitro Fertilization Process

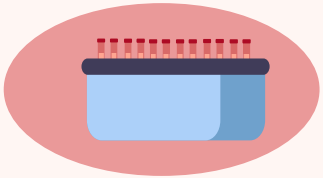
Stimulation



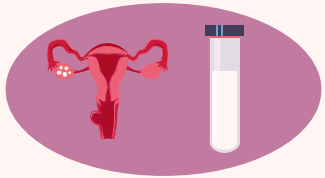
Egg Retrieval



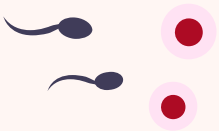
Fertilization



Embryo Culture

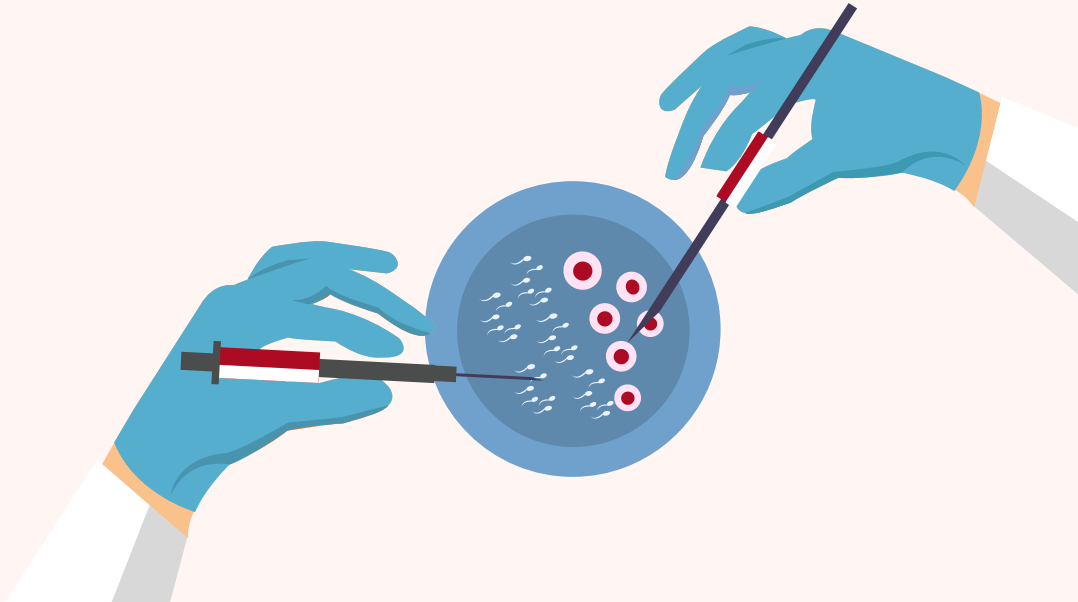


Embryo Transfer

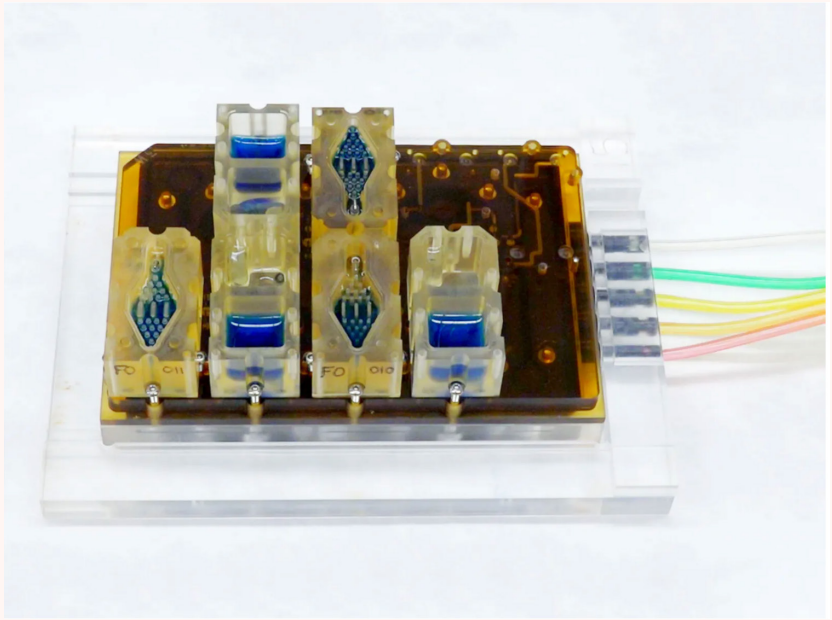


Current weaknesses

- Unknown Egg Quality
- Handling the eggs
- Staffing needs
- Hereditary genetic disorders



EVATAR: The Female Reproductive Organ System on a Chip



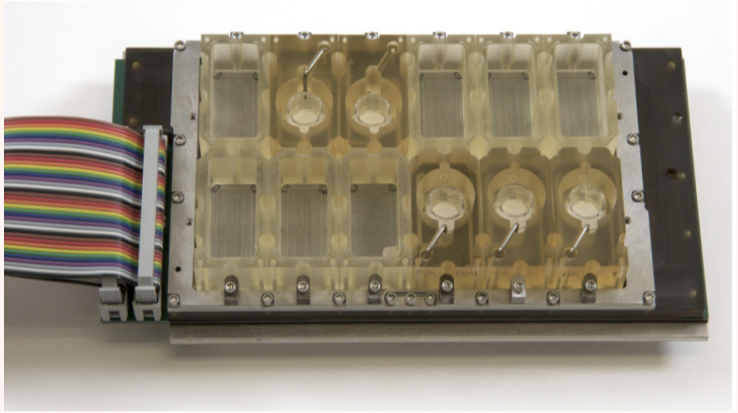
EVATAR Female Reproductive System on a Chip

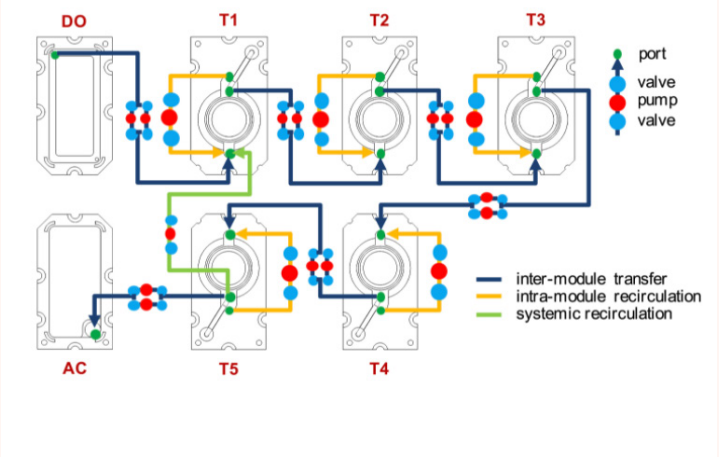
(McKinnon, 2017)

EVATAR Technology

- Each organ model is housed in a “module”, which is the first layer of the chip
- The second and third layers of the chip hold the channels and pumps that are used to carry nutrients, wastes, and other media through to each of the modules
- The pumps and channels act as the body’s circulatory system
- The chip connects to a computer, which acts as the brain of the system.

(McKinnon, 2017)

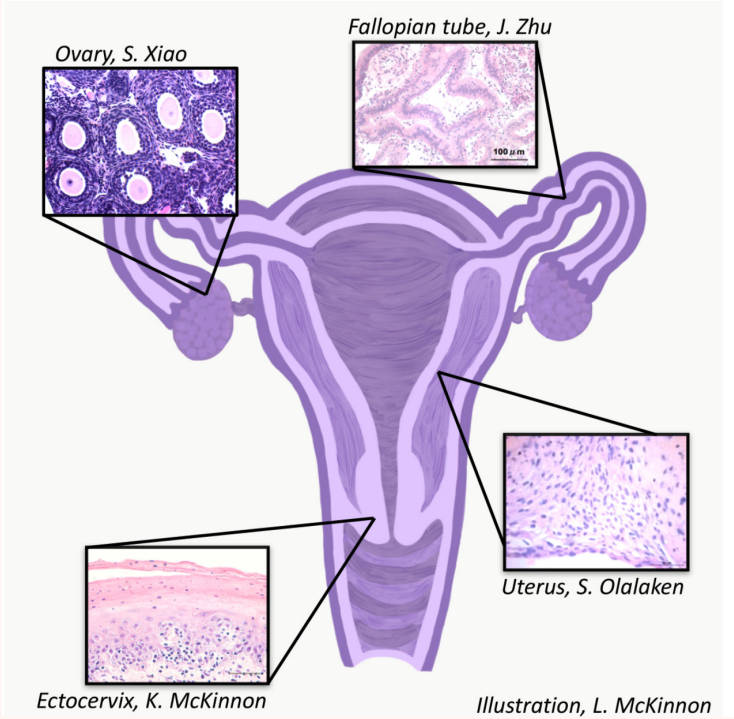




EVATAR BIOLOGY

- In this system, tissue from mouse ovaries were sampled in order to create the model ovary
- All of the other model organs were created from human tissue taken from hysterectomy patients after surgery.
- In the future, their goal is to be able to create personalized reproductive systems on a chip from the stem cells of individual patients

(McKinnon, 2017)



What is the Purpose of EVATAR?

1

Drug and Toxicology Study

- Help to solve the issue of conducting drug studies on human or animal subjects

2

Personalized Care

- Personalized chips using cells from individual patients would allow for faster and safer treatment/drug testing

(McKinnon, 2017)

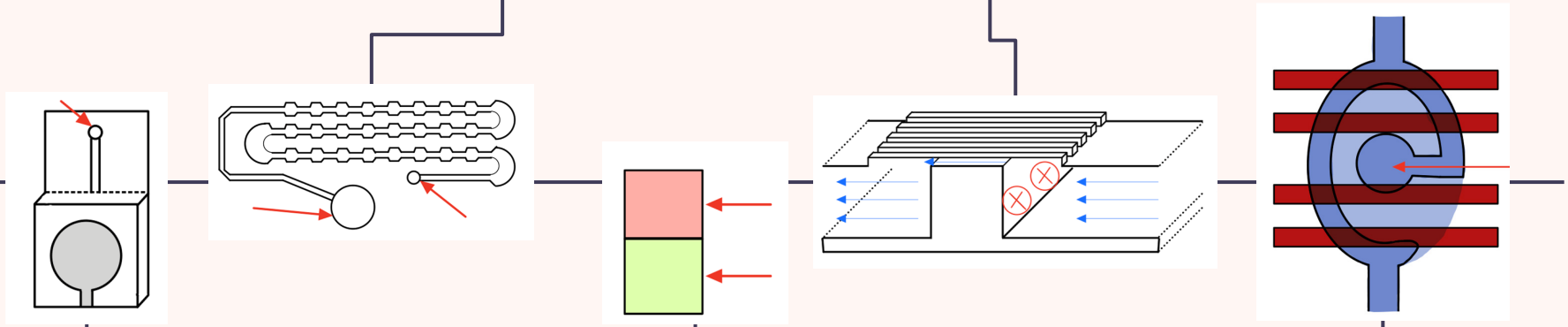
CHIP CONSTRUCTION

OOCYTE PROCESSING

Denude oocyte from cumulus cell mass

FERTILIZATION

Increase sperm-oocyte interaction



SPERM SELECTION

Select for most motile and functional sperm

OOCYTE SELECTION

Select high-quality oocyte (sedimentation rate)

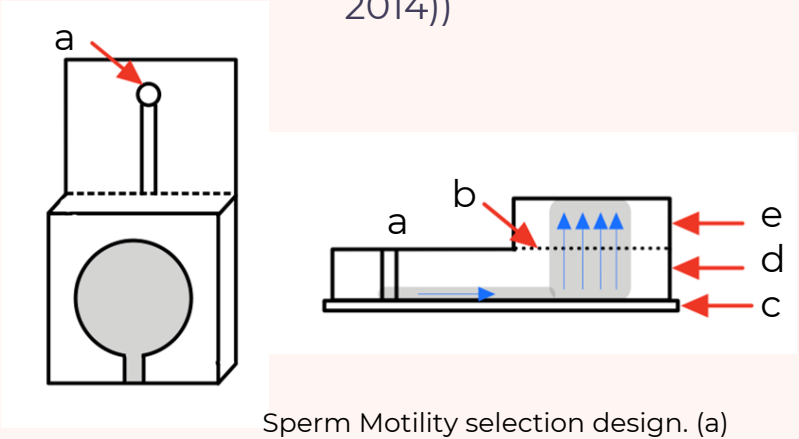
GROWTH

Biomimetic microenvironment

GAMETE PROCESSING

SPERM SELECTION

Polycarbonate membrane filter against gravity (Ashgar et. al, 2014))

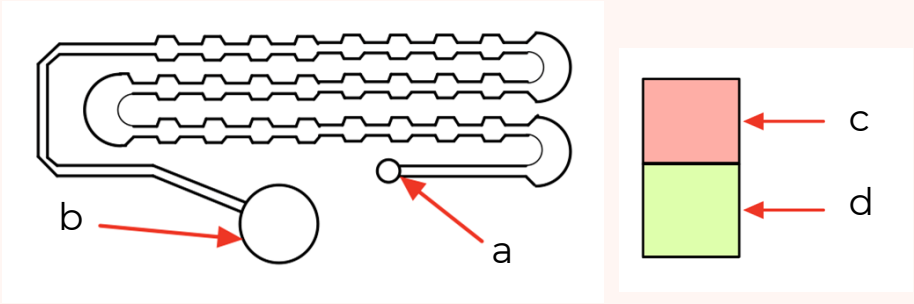


Sperm Motility selection design. (a) Sperm inlet, (b) polycarbonate membrane, (c) glass slide, (d) Semen flow up (e) retrieval chamber

OOCYTE PROCESSING

Denuding from cumulus cell mass (Weng et. al 2018)

Selecting oocyte based on sedimentation rate (Iwasaki et. al, 2018))



Oocyte processing design. (a) cumulus-oocyte complex inlet, (b) oocyte outlet, (c) low-quality oocyte, (d) high-quality oocyte (faster sedimentation rate)

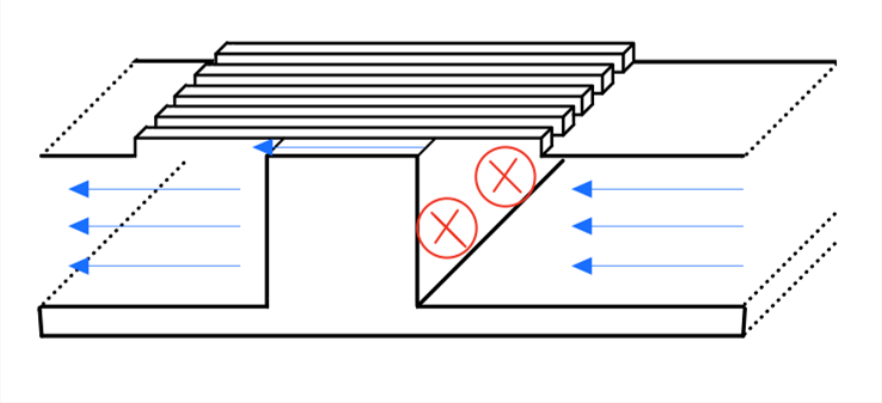
FERTILIZATION-ON-A-CHIP

KEY DESIGN FEATURES

Increase concentration of sperm in vicinity of oocyte

Minimize distress to oocyte

(Suh et. al 2006)



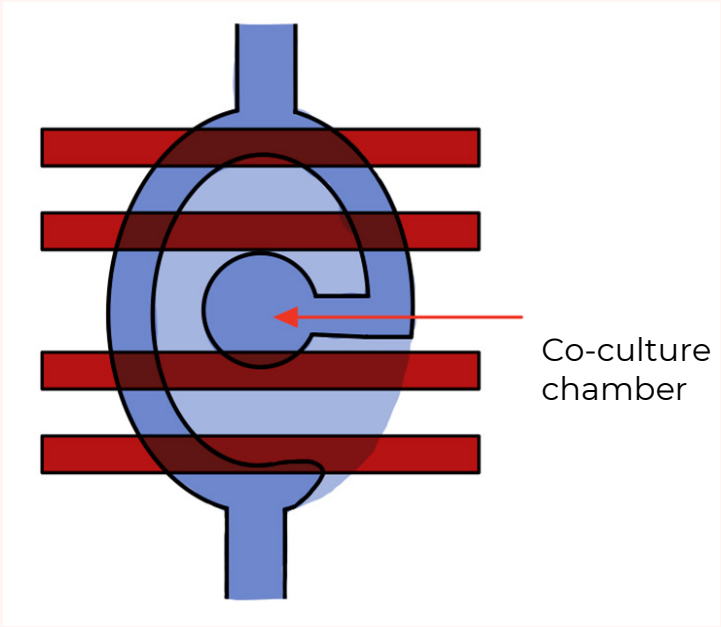
Fertilization-on-a-chip design. Blue arrows signify gravity-based flow of sperm through size-limited channels. Red (x)'s demonstrate the channel-stopped flow of oocytes.

CULTURE OF FERTILIZED EMBRYOS

KEY DESIGN FEATURES

1. Biomimetic microenvironment with stromal cells
1. Dynamic perfusion to enhance embryo growth.
1. Grow embryo until blastocyst- passive trapping for ease of removal

(Chen et. al 2021)
(Inagaki & Xu, 2007)



Embryo growth design. Microfluidic channels (red) cross a G-shaped channel allowing for dynamic perfusion for a biomimetic environment for embryo. Co-culture chamber with stromal cells.

FABRICATION

3 layers of PDMS structure
(2 layers of microfluidics)

Upper Channels: passive trapping system & G-shape chamber

Lower Channels: perfused channels

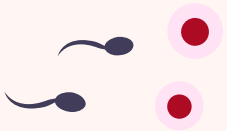
(double layer SU-8)

TESTING

Establish flow rates to minimize shear stress

Use oocyte/embryo analog (bead) for chip testing and semen samples

Parallel testing with traditional and chip methods measured by fertilization success and development



Testing to Compare Results

	Chip	Microdrops
# of Embryonic Cells	77 - 119	58 - 94
%Embryos Ready	80 %	20 %

(Inagaki & Xu, 2007)

LIMITATIONS / IMPROVEMENTS

LIMITATIONS

Cost of production and research

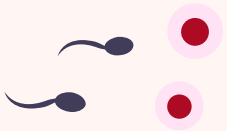
Doesn't address genetic abnormalities

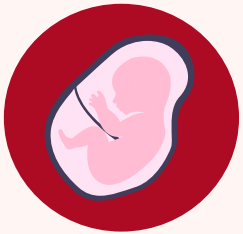
IMPROVEMENTS

Making it personalized to the parents needs

Improvements on fabrication techniques for lower cost efficiency

Co-culture improvements to reduce stromal cell death





Ethical Considerations

- Traditionally only for this fertility issues
- Scientists have concerns
  - Maternal age
  - Choosing sex
  - PGD diagnosis

(Sparrow, 2013)

Let's Take a Poll!

Help us come up with a name for our device!

https://forms.gle/KwdWxMVVVdq9mXL8A

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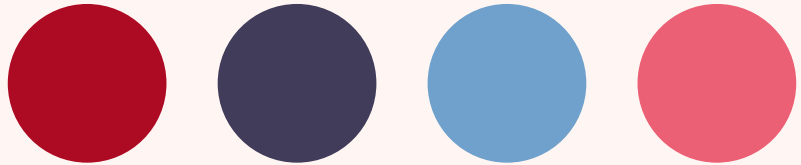
THANKS!



Do you have any questions?