
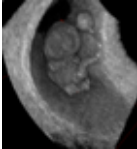


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University Medical Center Rotterdam



3-D virtual reality in early pregnancy imaging

Niek Exalto and Anton Koning



I-Space

Erasmus MC
University Medical Center Rotterdam



Dept of Bioinformatics

- Anton HJ Koning

Dept of Obstetrics and Gynaecology

- Christine M Verwoerd
- Eric AP Steegers



Dept of anatomy and embryology

- Maurice JB van den Hof

Dept of Obstetrics and Gynaecology

- Babette AM Lisman
- Kees Boer

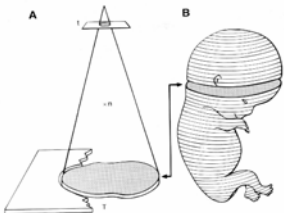
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3-D reconstructions

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Gustav Born 1876

- Solid reconstructions of embryos from stacking of wax plates
- $100 \text{ (magnification } n) \times 15 \mu\text{m (thickness)} = 1.5 \text{ mm plate thickness}$



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Carnegie Lab. of Embryology



Mr. Osborne O'Heard

- Stage 21, 24 mm
- Nr 632

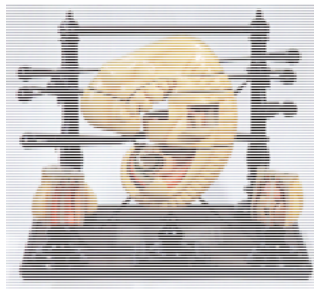


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Ziegler Sudio, Frieberg



- Adolf and Friedrich Ziegler (Streeter was a student)



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O'rahilly and Müller



Perspectomat

- Graphic reconstruction



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3-D Ultrasound



Limitations

- Only an impression
- On a flat screen
- Or on flat paper
- Time consuming



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Virtual reality



- Head mounted display (VR helm)

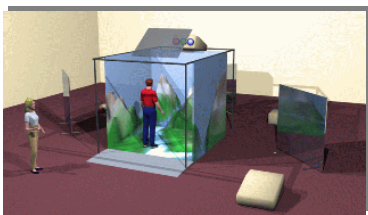


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Cave concept 1990



- More than one person
- Higher resolution
- Less "simulation sickness"

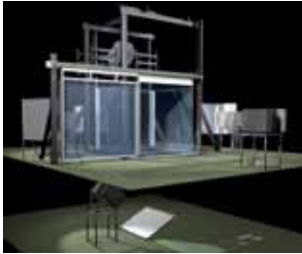


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Dept perception

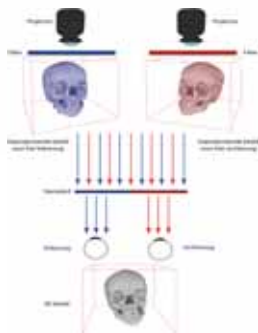


- Stereoscopic projection on walls, floor and ceiling (2x2 m)
- Dept perception by using a pair of Polaroid glasses



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Left and Right Polarised light



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CAVORE (Koning 1999)



- Images are viewed through glasses with polarizing lenses to perceive depth.
- The "hologram" is manipulated by means of a virtual pointer, controlled by a wireless joystick.
- Wireless tracking of the viewer's head allows the computer to provide a correct perspective and motion parallax.

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Joystick



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CAVORE = volume rendering appl

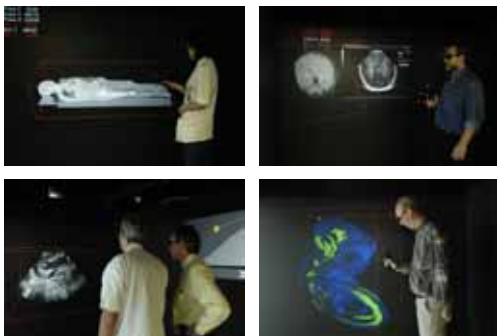


- Computer creates a hologram from the "volume"



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I-Space in Erasmus MC



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3D ultrasound and I-Space



- Ultrasound "volumes" (Voluson 730 Exp) were transferred to a computer
- Off line evaluation (4D View, GE Medical Systems) => BARCO I-Space



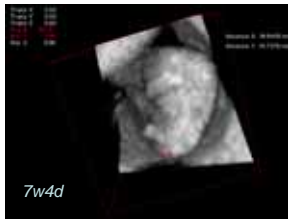
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Embryonic Staging Virtual Embryoscopy

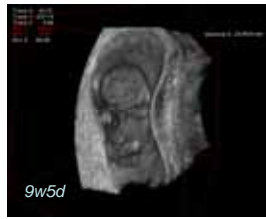


Verwoerd et al 2007

- IVF pregnancies 7 - 10 weeks
- CRL measurements
- Carnegie Stages (external morphological features)



7w4d



9w5d

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4th demension



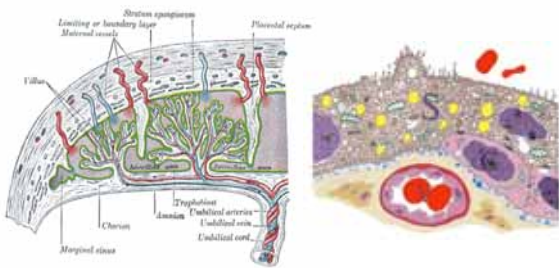
- Film 8w3d

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4th demension

- Film 12w3d

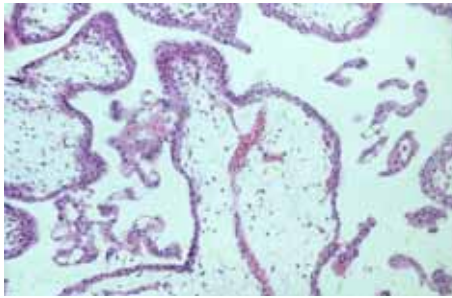
Vasculo-syncytial membrane



Intervillous space



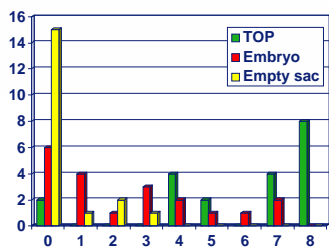
Normal vasculogenesis



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Vascularization

Meegdes et al 1988 Fertil Steril



| Vascularised Villi | % |
|--------------------|----|
| TOP (contr) | 89 |
| Embryo | 26 |
| Empty sac | 9 |

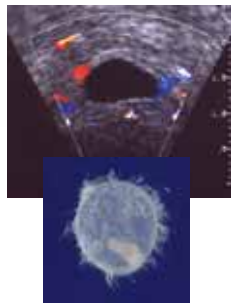
| Vascular density of vascularized villi | |
|--|----|
| TOP (contr) | 17 |
| Embryo | 5 |
| Empty sac | 4 |

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normal

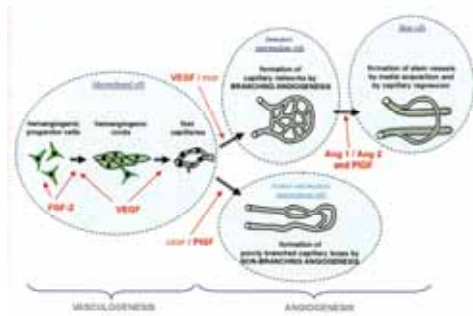


abnormal



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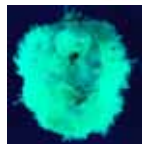
Vasculogenesis ~ Angiogenesis



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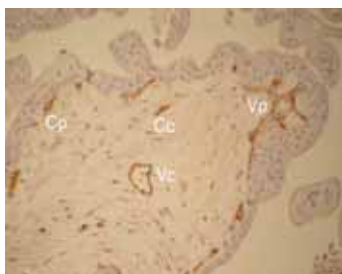
haematopoïesis

- o Vessels with a lumen from 6 weeks onwards
- o Mainly nucleated blood cells
 - From 8 weeks only nucleated cells
 - Between 10 and 12 weeks 10%
 - After 12 weeks sporadically




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Vascular elements (CD 31)

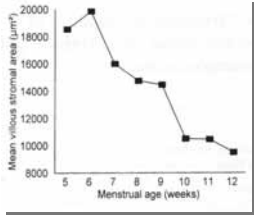
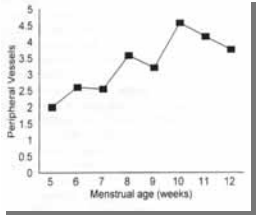


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First trimester Chorionic Villi

te Velde et al. 1997 Human Reprod

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Vascularization in first trimester

Lisman et al Fertil Steril 2002

| | n | cords | | vessels | | Total |
|-------------|----|-------|-----|---------|-----|-------|
| | | c | p | c | p | |
| TOP | 12 | 1.5 | 1.6 | 2.3 | 3.0 | 8,4 |
| Fetal death | 12 | 2.7 | 0.6 | 0.6 | 0.9 | 4,8 |
| Empty sac | 12 | 3.3 | 0.6 | 0.6 | 0.2 | 4,7 |

Vasculosyncytial membrane is not developed

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Late miscarriage

Lisman et al 2002

| 16 - 22 weeks | n | cords | | vessels | |
|---------------|----|-------|-----|---------|-----|
| | | c | p | c | p |
| Normal | 4 | 0.8 | 0.7 | 4.5 | 5.3 |
| Chrom abn | 10 | 2.5 | 2.7 | 3.2 | 2.7 |
| IUGR | 13 | 5.6 | 3.2 | 2.9 | 1.7 |

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Flow

1e trimester 15 wk

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3D reconstruction

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Confocal microscopy

6 wk 9 wk

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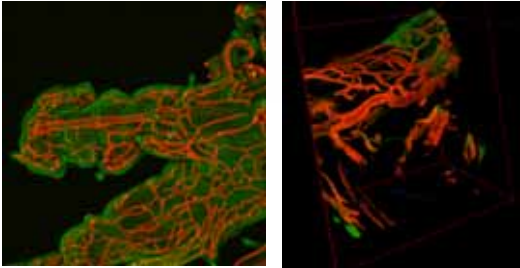
Molar pregnancy



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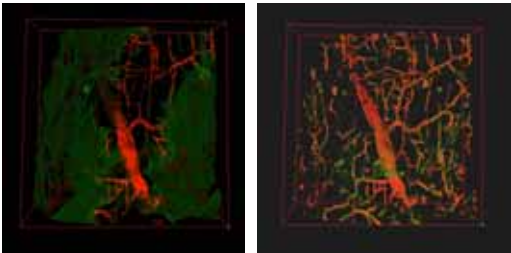
Confocal microsc => I-Space



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Microdissection 8 weeks

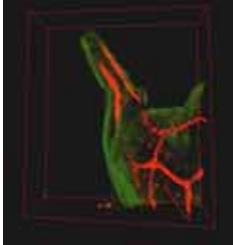


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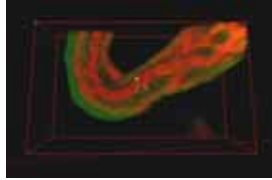
Microdissection

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Clip plane



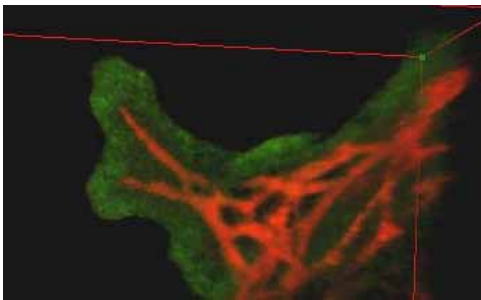
Measurements with callipers



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Sprout 12 weeks

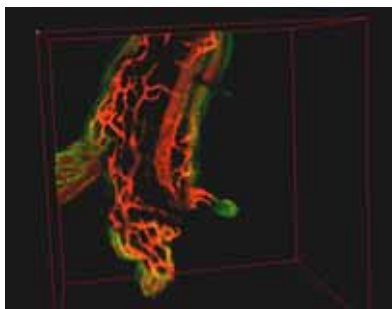
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Circulation? 11 weeks

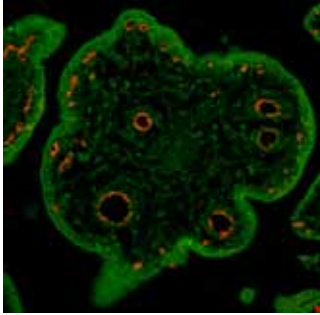
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Conclusion

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I-Space
virtual reality

Ultrasound
microscopy

Organogenesis
vasculosyncitial
membrane

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