

# Kent Academic Repository

## Full text document (pdf)

### Citation for published version

Taylor, Tyl H. and Stankewicz, Tiffany and Katz, Seth L. and Patrick, Jennifer L. and Johnson, Lauren and Griffin, Darren K. (2019) Preliminary assessment of aneuploidy rates between the polar, mid and mural trophectoderm. *Zygote* . pp. 1-4. ISSN 0967-1994.

### DOI

<https://doi.org/10.1017/S0967199419000637>

### Link to record in KAR

<https://kar.kent.ac.uk/79520/>

### Document Version

Author's Accepted Manuscript

#### Copyright & reuse

Content in the Kent Academic Repository is made available for research purposes. Unless otherwise stated all content is protected by copyright and in the absence of an open licence (eg Creative Commons), permissions for further reuse of content should be sought from the publisher, author or other copyright holder.

#### Versions of research

The version in the Kent Academic Repository may differ from the final published version.

Users are advised to check <http://kar.kent.ac.uk> for the status of the paper. **Users should always cite the published version of record.**

#### Enquiries

For any further enquiries regarding the licence status of this document, please contact:

[researchsupport@kent.ac.uk](mailto:researchsupport@kent.ac.uk)

If you believe this document infringes copyright then please contact the KAR admin team with the take-down information provided at <http://kar.kent.ac.uk/contact.html>

**Preliminary assessment of aneuploidy rates between the  
polar, mid and mural trophectoderm**

Journal:	<i>Zygote</i>
Manuscript ID	ZYG-2019-0054.R2
Manuscript Type:	Research Article
Date Submitted by the Author:	12-Sep-2019
Complete List of Authors:	Taylor, Tyl; Reproductive Endocrinology Associates of Charlotte, IVF Stankewicz, Tiffany; Main Line Fertility, IVF; University of Kent, Biosciences Katz, Seth; Reproductive Endocrinology Associates of Charlotte, IVF Patrick, Jennifer; Reproductive Endocrinology Associates of Charlotte, IVF Johnson, Lauren; Reproductive Endocrinology Associates of Charlotte, IVF Griffin, Darren; University of Kent, Biosciences
Keywords:	preimplantation genetic screening, aneuploidy, embryo biopsy, comprehensive chromosome screening, IVF

SCHOLARONE™  
Manuscripts

Preliminary assessment of aneuploidy rates between the polar, mid and mural trophectoderm

Tyl H. Taylor, PhD.<sup>a,\*</sup>, Tiffany Stankewicz<sup>b,c</sup>, Seth L. Katz M.D.<sup>a</sup>, Jennifer L. Patrick PhD,  
Lauren Johnson, MD<sup>a</sup>, Darren K. Griffin, Ph.D.<sup>b</sup>

<sup>A</sup> Reproductive Endocrinology Associates of Charlotte

1524 E Morehead St

Charlotte, NC, 28207

(P) 704-343-3400

(F) 704-370-0427

<sup>B</sup> University of Kent

School of Biosciences

Canterbury, United Kingdom

<sup>c</sup> Main Line Fertility

Bryan Mawr, PA

\*(e) [tyltaylor@gmail.com](mailto:tyltaylor@gmail.com)

## Abstract

The objective of this study is to compare aneuploidy rates between three distinct areas of the human trophectoderm: mural, polar, and a region in between these two locations termed the “mid” trophectoderm. This is a cohort study on IVF patients undergoing comprehensive

chromosome screening at the blastocyst stage at a private IVF clinic. All embryos underwent assisted hatching on day 3 with blastocyst biopsy and comprehensive chromosome screening. Biopsied blastocysts were divided into three groups depending on which area (polar, mid, or mural) of the trophectoderm was protruding from the zona pellucida and biopsied. Aneuploidy rates were significantly higher with cells from the polar region of the trophectoderm (56.2%) compared to cells removed from the mural region of the trophectoderm (30.0%;  $P=0.0243$ ). A comparison of all three areas combined also showed a decreasing trend, but it did not reach clinical significance, polar (56.2%), mid (47.4%), and mural trophectoderm (30.0%;  $P=0.1859$ ). The non-concordance demonstrated between polar and mural trophectoderm can be attributed to biological occurrences including chromosomal mosaicism or procedural differences between embryologists.

**Keywords:** Preimplantation genetic screening; aneuploidy; embryo biopsy; comprehensive chromosome screening; IVF

## Introduction

Aneuploidy refers to the presence of absence of whole chromosomal abnormalities. In order for a euploid live birth to occur, chromosomes must divide equally in the developing fetus. Any abnormal division during development can have disastrous downstream effects, leading to poor embryo development, failed implantation, obstetric complications, pregnancy loss, stillbirth, neonatal congenital abnormality, and infertility. Thus, preimplantation genetic testing (PGT) has been created to test for aneuploidy prior to implantation thereby allowing the transfer of euploid embryos. The transferring of euploid embryos has demonstrated a higher pregnancy rate, lower miscarriage rate, and higher live birth rate than the transfer of untested embryos (Yang *et al.*, 2012; Forman *et al.*, 2013; Scott *et al.*, 2013). Unfortunately, these studies are limited due to good prognosis patients or are not based on “intent to treat”. More recent research has demonstrated that embryos diagnosed as mosaic, having a mixture of euploid and aneuploid cell lines, and even embryos diagnosed as aneuploid can produce live births (Munne *et al.*, 2017 and Patrizio *et al.*, 2019).

The blastocyst represents the first stage of differentiation in preimplantation development. The blastocyst differentiates into the inner cell mass (ICM), which will become the fetus and the trophoctoderm that will become the placenta. The trophoctoderm itself is subdivided into two areas based on the location of the ICM: the mural trophoctoderm, the area furthest away from the ICM, and the polar trophoctoderm, the area adjacent to the ICM. Typically, during PGT cells are removed from the mural trophoctoderm as not to expose the ICM to the damage caused by the laser (Taylor *et al.*, 2014). However, blastocyst biopsy is not standardized, which can lead to inter and intra differences with embryologists in terms of the area of biopsied.

It has been suggested that ploidy is consistent throughout the trophectoderm (i.e. that all cells have the same karyotype) (Northrop *et al*, 2010; Capalbo *et al*, 2013). Thus, cells removed from the mural trophectoderm should mirror the chromosome content of the remaining cells. To test this hypothesis, this study aimed to compare aneuploidy rates between three distinct areas of trophectoderm: mural, polar, and a region in between these two locations termed the “mid” trophectoderm.

## **Methods**

This study was deemed exempt by Sterling IRB because it only incorporated routine IVF procedures. Only patients undergoing in vitro fertilization with PGT between January 2012 and April 2013 at Reproductive Endocrinology Associates of Charlotte (Charlotte, North Carolina, USA) were included in this study. All biopsy specimens were sent to Genesis Genetics (Detroit, Michigan, USA) where samples underwent next generation sequencing (NGS).

Briefly, all fertilized oocytes were cultured to day 3 and assisted hatching (AH) was performed. Embryos were placed back into incubator and cultured to the blastocyst stage. Embryos whose trophectoderm was hatching out of the zona pellucida (ZP) underwent the biopsy procedure. Biopsied blastocysts were divided into three groups depending on which area (polar, mid, or mural) of the trophectoderm was protruding from the ZP and was biopsied.

## **Egg Retrieval and Embryo Culture**

All retrieved oocytes were designated for intracytoplasmic sperm injection (ICSI). Oocytes were retrieved, trimmed of blood, and stripped of cumulus cells as described by Taylor

and colleagues (Taylor *et al.*, 2008). Oocytes were separated based on maturity and placed into a 60 mm dish (Thermo scientific, Rochester, New York, USA) with approximately 100  $\mu$ L drops of continuous culture media (CSC; Irvine Scientific, Santa Ana, California, USA) supplemented with 10% serum substitute supplement (SSS; Irvine Scientific, Santa Ana, California, USA) and overlaid with oil (Irvine Scientific, Santa Ana, California, USA). After grading, the dish containing the oocytes was placed into an incubator at 37°C, 6% CO<sub>2</sub> and 5% O<sub>2</sub> for 2-3 hours. After 2 hours, all oocytes presenting with a polar body underwent ICSI'd as described by Nagy and colleagues (1995), placed back into the same dish, and put back into the incubator.

The next day, 16-18 hours post ICSI, oocytes were evaluated for proper fertilization. Embryos that exhibited two pronuclei were group cultured in a fresh dish of CSC+10%SSS overlaid with oil and placed back into the incubator. Embryos were not viewed on day 2.

On day 3, the embryos were removed from the incubator, graded, and AH was performed on all cleaving embryos with the aid of a laser (Zilos-tk, Hamilton Thorne, Beverly, Mass, USA). Using a pulse of 610  $\mu$ s, the ZP was breached with 2-3 shots of the laser (Zilos-tk, Hamilton Thorne, Beverly, Maine, USA). The ZP was breached where there were no blastomeres that could be directly affected by the laser pulse. After breaching the ZP with the laser, the embryos were left in the same drop and placed back into the incubator.

On the morning of day 5 (112-115 hours post insemination) and day 6 (136-139 hours post insemination), embryos were removed from the incubator, blastocysts were graded based on Schoolcraft and colleagues (1999), and those blastocysts that had a good or fair trophoderm protruding from the ZP along with good or fair quality ICM were biopsied. Blastocysts were only viewed once in the morning and at no other times. If the blastocysts were not suitable for biopsy

in the morning of day 5, they were reevaluated on the morning of day 6. Blastocysts were biopsied on day 5 or day 6, whichever day they met the biopsy criteria. If embryos did not meet the criteria for biopsy on day 6, they were discarded. There was no morphological difference between blastocysts that were biopsied on day 5 or day 6 other than the embryos needed an extra day to reach the proper stage for biopsy.

### **Trophectoderm biopsy**

Blastocysts that presented with a good or fair quality ICM and trophoctoderm were placed in a drop of modified human tubal fluid (Irvine scientific, Santa Ana, California, USA) + 10% SSS (Irvine scientific, Santa Ana, California, USA). Suction was applied to the blastocysts via a holding pipette (Humagen, Charlottesville, Virginia, USA). A biopsy pipette (Humagen, Charlottesville, Virginia, USA) gently aspirated the trophoctoderm into the biopsy needle. A laser (Zilos-tk, Hamilton Thorne, Beverly, Maine, USA), with a pulse length of 610µm, was used to “cut” the trophoctoderm from the blastocyst, taking care not to expose the trophoctoderm to unnecessary laser pulses. The piece of trophoctoderm was prepped for next generation sequencing.

### **Results**

In total, 166 blastocysts were biopsied, 48 from the polar trophoctoderm, 78 from the mid trophoctoderm, and 40 from the mural trophoctoderm. There was no significant difference in maternal age between the three groups, i.e. 35.8±4.9 years, 34.9±4.4 years, and 35.2±5.1 years, for the plural, mid, and mural trophoctoderm, biopsied groups respectively (Table 1; P=0.8024). Aneuploidy rates were 27/48 in polar trophoctoderm group (56.2%), 37/78 in the mid trophoctoderm group (47.4%), and 12/40 in the mural trophoctoderm group (30.0%; Table 1;



P=0.1859). In a direct comparison between mural and polar trophoctoderm, aneuploidy rates were significantly higher (Table 2; P=0.0243).

## Discussion

The hypothesis that aneuploidy is evenly distributed throughout the trophoctoderm cannot be supported by this study. Aneuploidy rates were significantly higher when cells were taken from the polar region of the trophoctoderm (56.2%) compared to cells removed from the mural region of the trophoctoderm (30.0%; Table 2). These data also demonstrates a strong trend in decreasing aneuploidy from the polar (56.2%), mid (47.4%), and mural trophoctoderm (30.0%; Figure 1). The non-concordance demonstrated between polar and mural trophoctoderm can be attributed to biological occurrences or procedural differences.

Biologically, Hogan and Tilly (Hogan and Tilly, 1978) dissected mouse ICM from the trophoctoderm and left the ICM in culture. Within five days, some of the individual ICM's had the appearance of a blastocyst. Moreover, the individual ICM's derived trophoblast giant cells. These studies suggest that cells from the ICM feed the trophoctoderm. It is unknown if this mechanism is present in human embryos; however, if it were, it could explain these data. If the ICM were mosaic and contained equal proportions of aneuploid and euploid cells, then aneuploid cells would feed into the trophoctoderm at the same rate as euploid cells. Once in the trophoctoderm, the euploid cells would proliferate at a faster rate than aneuploid cells (Ruangvutilert *et al.*, 2000). Thus, the blastocyst could have a higher proportion of aneuploid cells in the polar compared to the mural trophoctoderm, which these data supports (Figure 2). Conversely, this theory would suggest that the blastocyst may be able to allocate aneuploid cells

to the trophectoderm thereby correcting its chromosome state by the elimination of aneuploid cells from the ICM. Research using FISH and array-based techniques have found no evidence of this correction mechanism in place for human blastocysts (Johnson *et al.*, 2000; Northrop *et al.*, 2010; Evsikov and Verlinsky, 1998; Derhaag *et al.*, 2003; Fragouli *et al.*, 2008).

Another biological reason for the discrepancy between regions of the trophectoderm could be the blastocyst preparing for implantation. During implantation, the blastocyst embeds itself with the ICM (polar trophectoderm) against the uterine wall. In order to invade into the uterine wall, the cytotrophoblasts, which are located in the polar region, have been shown to induce aneuploidy (Weier *et al.*, 2005). These data suggests that aneuploidy is higher in the polar region, possibly because the embryo is undergoing chromosomal changes to prepare for implantation. Unfortunately this study did not examine implantation rates between the three different categories, so it is unknown if aneuploidy in the polar region is detrimental. However, transfers of “aneuploid” or mosaic blastocysts have resulted in euploid live births suggesting that some aneuploidy and mosaicism may not be clinically significant (Scott *et al.*, 2012; Greco *et al.*, 2015; Taylor *et al.*, 2014; Munne *et al.*, 2017; Patrizio *et al.*, 2019). Both of these biological occurrences suggest that mosaicism is a common phenomenon within the human blastocyst (Taylor *et al.*, 2014b).

Literature is currently lacking in terms of the effects of the biopsy procedure on the outcomes of PGT cycles. For example, in this study, the embryologist has to biopsy from the mural trophectoderm. Because of its proximity to the ICM, it is possible that some ICM cells were removed with the trophectoderm during the biopsy. Unfortunately, the level of contamination between the ICM and trophectoderm during the biopsy is unknown. However, this may not affect the PGT result as research has indicated a high concordance between the two regions (Johnson *et al.*, 2000; Capalbo *et al.*, 2013). Interestingly, with the advent of NGS and its increase in the

detection of mosaicism, the biopsy procedure has become a variable. If embryologist “A” biopsies two cells from the blastocyst and both are normal or abnormal, mosaicism will not be detected. However, if embryologist “B” biopsies 10 cells from the blastocyst and six cells are aneuploid and four cells are euploid, mosaicism will be detected simply due to the increase number of cells biopsied. Research has also suggested that the majority of abnormalities at the blastocyst stage are mitotic in origin, suggesting that with enough cells present, PGT results could be altered (McCoy *et al.*, 2015).

Ideally, one should biopsy from the polar, mid, and mural trophectoderm from a single blastocyst; however, this was not possible because these were patients undergoing IVF and not blastocysts donated to research. Northrop and colleagues (2010) examined three separate trophectoderm sections from the same blastocyst and demonstrated a concordance rate of 80% (40/50 blastocysts), but this study did not record the location of the trophectoderm samples in relation to the ICM. Another limitation was performing AH on day 3. AH allows for premature hatching which may disrupt the true chromosomal makeup within the embryo or influence cell distribution. It is possible that the heat generated from the laser could disrupt cell junctions and impact further embryological development, possibly allowing for the premature expulsion of cells (White *et al.*, 2018). However, research in the mouse demonstrates that embryos hatch equally from the polar, mid, and mural trophectoderm, suggesting a limited impact on the AH procedure (Schimmel *et al.*, 2014). Our data is similar, of the 166 blastocysts, there was no difference between which area (polar, mid, or mural) hatched out of the blastocyst, 37.8%, 30.7%, 31.5%, respectively (P=NS). Further research is needed whereby AH is not performed and blastocysts are not exposed to the laser until biopsy, day 5 or 6.

Most of the research with mosaicism at the blastocyst stage deals with the reanalysis of array comparative genomic hybridization samples or the mixing of known cell lines to determine the percent mosaicism present in the entire blastocyst (Ruttanajit *et al.*, 2016). The only way we can understand aneuploidy and blastocyst morphology is to isolate individual cells within the blastocyst and effectively “map” the cells, creating a virtual image of the blastocyst (Taylor *et al.*, 2016). This study has already been performed and although cost prohibitive, larger studies are certainly warranted.

In conclusion, these data do not support the hypothesis that aneuploidy is evenly distributed throughout the trophectoderm. This study adds to the pool of data that may help patients and clinicians understand why some embryos diagnosed as “euploid” fail to implant. Further research is needed to better understand aneuploidy at the blastocyst stage and its clinical consequences.

### **Financial Support**

This research received no specific grant from any funding agency, commercial or not-for-profit sectors

### **Conflicts of Interest**

None.

### **Ethical Standards**

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

## References

- Capalbo A, Wright G, Elliott T, Ubaldi FM, Rienzi L, Nagy ZP. FISH reanalysis of inner cell mass and trophectoderm samples of previously array-CGH screened blastocysts shows high accuracy of diagnosis and no major diagnostic impact of mosaicism at the blastocyst stage. *Hum Reprod.* 2013;28:2298-307.
- Capalbo A, Ubaldi FM, Cimadomo D, Maggiulli R, Patassini C, Dusi L, Sanges F, Buffo L, Venurella R, Rienzi L. Consistent and reproducible outcomes of blastocyst biopsy and aneuploidy screening across different biopsy practitioners; a multicenter study involving 2586 embryo biopsies. *Hum Reprod.* 2016;31(1):199-208.
- Derhaag JG, Coonen E, Bras M, Bergers Janssen JM, Ignoul-Vanvuchelen R, Geraedts JP, Evers JL, Dumoulin JC. Chromosomally abnormal cells are not selected for the extra-embryonic compartment of the human preimplantation embryo at the blastocyst stage. *2003;18(12):2565-74.*
- Evsikov S and Verlinsky Y. Mosaicism in the inner cell mass of human blastocysts. *Hum Reprod.* 1998;13(11):3151-5.
- Forman EJ, Hong KH, Keery KM, Tao X, Taylor, Levy B, et al. In vitro fertilization with single euploid blastocyst transfer: a randomized controlled trial. *Fertil Steril.* 2013; 100:100-7.
- Fragouli E, Lenzi M, Ross R, Katz-Jaffe M, Schoolcraft WB, Wells D. Comprehensive molecular cytogenetic analysis of the human blastocyst stage. *Hum Reprod.* 2008;23(11):2596-608.
- Greco E, Minasi MG, Fiorentino F. Healthy babies after intrauterine transfer of mosaic aneuploid blastocysts. *N Engl J Med.* 2015;373:2089-90.
- Hogan B and Tilly R. In vitro development of inner cell masses isolated immunosurgically from mouse blastocysts. I. Inner cell masses from 3.5-day p.c. blastocysts incubated for 24 h before immunosurgery. *J Embryol Exp Morphol* 1978;45:93-105.
- Johnson DS, Cinnioglu C, Ross R, Filby A, Gemelos G, Hill M, Ryan A, Smotrich D, Rabinowitz M Murray MJ. Comprehensive analysis of karyotypic mosaicism between trophectoderm and inner cell mass. *Mol Hum Reprod.* 2000;16(12):944-9.
- McCoy RC, Demko ZP, Ryan A, Banjevic M, Hill M, Sigurjonsson S, Rabinowitz M, Petrov DA. Evidence of selection against mitotic-origin aneuploidy during preimplantation development. *Plos Genet.* 2015;11(10).

- Munne S, Blazek J, Large M, Martinez-Ortiz PA, Nisson H, Liu E, Tarozzi N, Borini A, Becker A, Zhang J, Maxwell S, Grifo J, Barbariya D, Wells D, Fragouli E. Detailed investigation into the cytogenetic constitution and pregnancy outcome of replacing mosaic blastocysts detect with the use of high-resolution next-generation sequencing. *Fertil Steril*. 2017;108:62-71.
- Nagy ZP, Liu J, Cecile J, Silber S, Devroey P, van Steirteghem A. Using ejaculated, fresh, and frozen-thawed epididymal and testicular spermatozoa gives rise to comparable results after intracytoplasmic sperm injection. *Fertil Steril* 1995;63(4):808-15.
- Northrop LE, Treff NR, Levy B, Scott RT Jr. SNP microarray-based 24 chromosome aneuploidy screening demonstrates that cleavage-stage FISH poorly predicts aneuploidy in embryos that develop to morphologically normal blastocysts. *Mol Hum Reprod*. 2010;16(8):590-600.
- Patrizio P, Shoham G, Shoham Z, Leong M, Barad DH, Gleicher N. Worldwide live births following transfer of chromosomally “abnormal” embryos after PGT/A. Results of a worldwide web-based survey. *J Assist Reprod Genet*. 2019;6.
- Ruangvutilert P, Delhanty JD, Serhal P, Simpoloulou M, Rodeck CH, Harper JC. FISH analysis on day 5 post-insemination of human arrested and blastocyst stage embryos. *Prenat Diagn* 2000;20(7):552-60.
- Ruttanajit T, Chanchamroen S, Cram DS, Sawakwongpra K, Suksalak W, Leng X, Fan J, Wang L, Yao Y, Quangkananurug W. Detection and quantitation of chromosomal mosaicism in human blastocysts using copy number variation sequencing. 2016;36(2):154-62.
- Schimmel T, Cohen J, Saunders H, Alikani M. Laser-assisted zona pellucida thinning does not facilitate hatching and may disrupt the in vitro hatching process: a morphokinetic study in the mouse. *Hum Reprod*. 2014;29(12):2670-9.
- Schoolcraft WB, Gardner DK, Lane M, Scenker T, Hamilton F, Meldrum DR. Blastocyst culture and transfer: analysis of results and parameters affecting outcome in two in vitro fertilization programs. *Fertil Steril* 1999;72(4):604-9.
- Scott RT Jr, Ferry K, Su J, Tao X, Scott K, Treff NR. Comprehensive chromosome screening is highly predictive of the reproductive potential of human embryos: a prospective, blinded, nonselection study. *Fertil Steril* 2012;97(4):870-5.
- Scott RT Jr., Upham KM, Forman EJ, Hong KH, Scott KL, Taylor D, Tao X, Treff NR. Blastocyst biopsy with comprehensive chromosome screening and fresh embryo transfer significantly increases in vitro fertilization implantation and delivery rates: a randomized controlled trial. *Fertil Steril* 2013;100:697-703.

- Scott RT Jr, Upham KM, Forman EJ, Zhao T, Treff NR. Cleavage-stage biopsy significantly impairs human embryonic implantation potential while blastocyst biopsy does not: a randomized and paired clinical trial. *Fertil Steril* 2013;100:624-30.
- Taylor TH, Wright G, Jones-Colon S, Mitchell-Leef D, Kort HI, Nagy ZP. Comparison of ICSI and conventional IVF in patients with increased oocyte maturity. *Reprod Biomed Online*. 2008;17:46-52.
- Taylor TH, Patrick JL, Gitlin SA, Wilson JM, Crain JL, Griffin DK. Comparison of aneuploidy, pregnancy and live birth rates between day 5 and day 6 blastocysts. *Reprod Biomed Online*. 2014;29:305-10.
- Taylor TH, Gitlin SA, Patrick JL, Crain JL, Wilson JM, Griffin DK. The origin, mechanisms, incidence and clinical consequences of chromosomal mosaicism in humans. *Hum Reprod Update*. 2014b;20:571-81.
- Taylor TH, Griffin DK, Katz SL, Crain JL, Johnson L, Gitlin SA. Technique to “map” chromosomal mosaicism at the blastocyst stage. *Cytogenet Genome Res*. 2016;149(4):262-266.
- Weier JF, Weier HU, Jung CJ, Gormley M, Zhou Y, Chu LW, Genbacev O, Wright AA, Fisher SJ. Human cytotrophoblasts acquires aneuploidies as they differentiate to an invasive phenotype. *Dev Biol*. 2005;279(2):420-32.
- White MD, Zenker J, Bissiere S, Plachta N. Instructions for assembling the early mammalian embryo. *Dev Cell*. 2018;45:667-79.
- Yang Z, Liu J, Collins GS, Salem SA, Liu X, Lyle SS, et al. Selection of single blastocysts for fresh transfer via standard morphology assessment alone and with array CGH for good prognosis IVF patients: results from a randomized pilot study. *Mol Cytogenet*. 2012;5:24.

Table 1: A comparison of aneuploidy rates between the polar, mid, and mural trophoctoderm.

	Polar	Mid	Mural	P value
Avg. Age (years)	35.8±4.9	34.9±4.4	35.2±5.1	0.8024 <sup>1</sup>
No. Blastocyst	48	78	40	0.1859 <sup>2</sup>
No. Aneuploid	27 (56.2%)	37 (47.4%)	12 (30.0%)	

<sup>1</sup> Kruskal-Wallis test<sup>2</sup> Chi-square test



Table 2: A comparison of aneuploidy rates between polar and mural trophoderm.

	Polar	Mural	P Value
Avg. Age	35.8±4.9	35.2±5.1	0.8417 <sup>1</sup>
No. Blastocyst	48	40	0.0243 <sup>2</sup>
No. Aneuploidy	27 (56.2%)	12 (30.0%)	

<sup>1</sup> Kruskal-Wallis test<sup>2</sup> Chi-square test

Figure 1: Aneuploidy rates between polar, mid, and mural trophoctoderm.

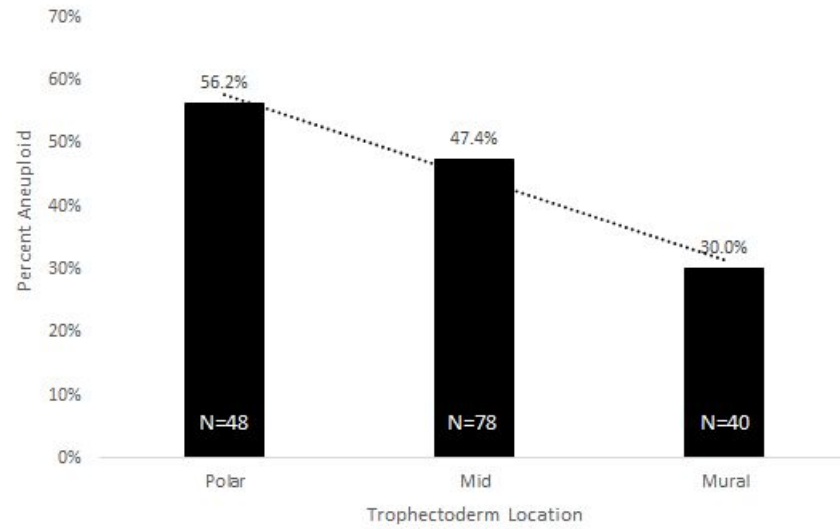


Figure 2: A figure showing the direction of cellular migration from the inner cell mass out into the trophoctoderm.

