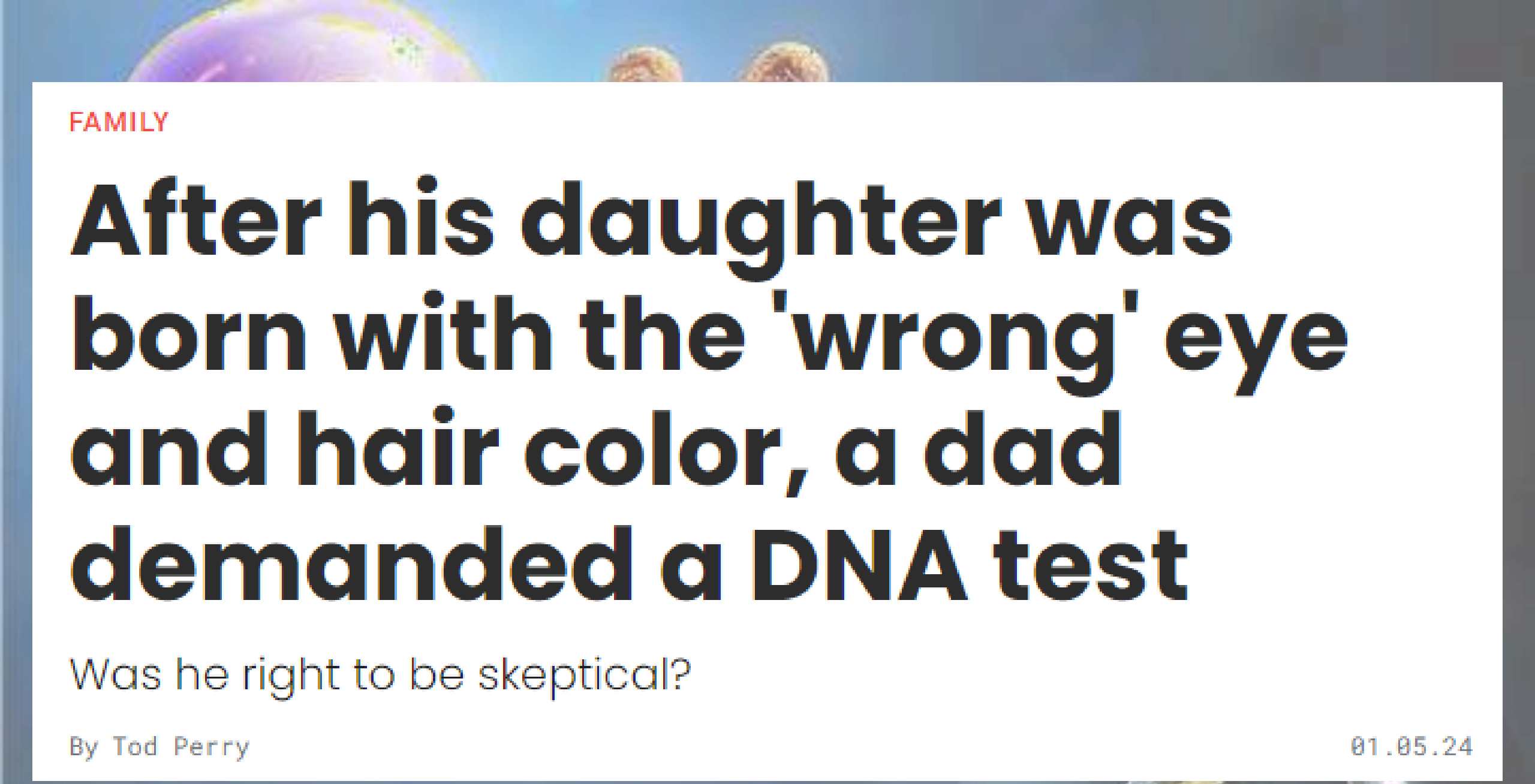


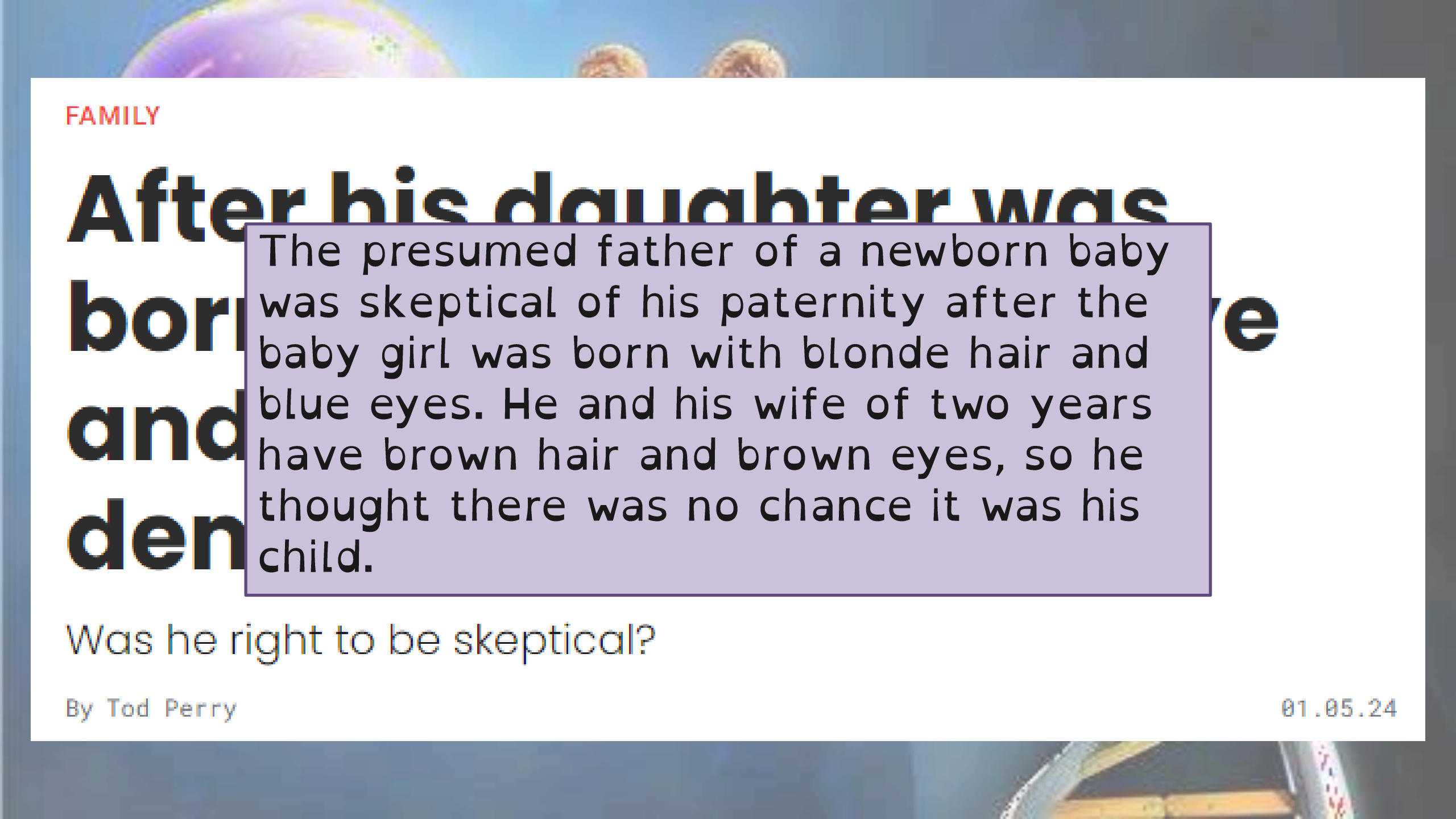
FAMILY

After his daughter was born with the 'wrong' eye and hair color, a dad demanded a DNA test

Was he right to be skeptical?

By Tod Perry

01.05.24



FAMILY

After his daughter was born and den ve

The presumed father of a newborn baby was skeptical of his paternity after the baby girl was born with blonde hair and blue eyes. He and his wife of two years have brown hair and brown eyes, so he thought there was no chance it was his child.

Was he right to be skeptical?

By Tod Perry

01.05.24

Genetic Variance

Reproduction on a Cellular Level

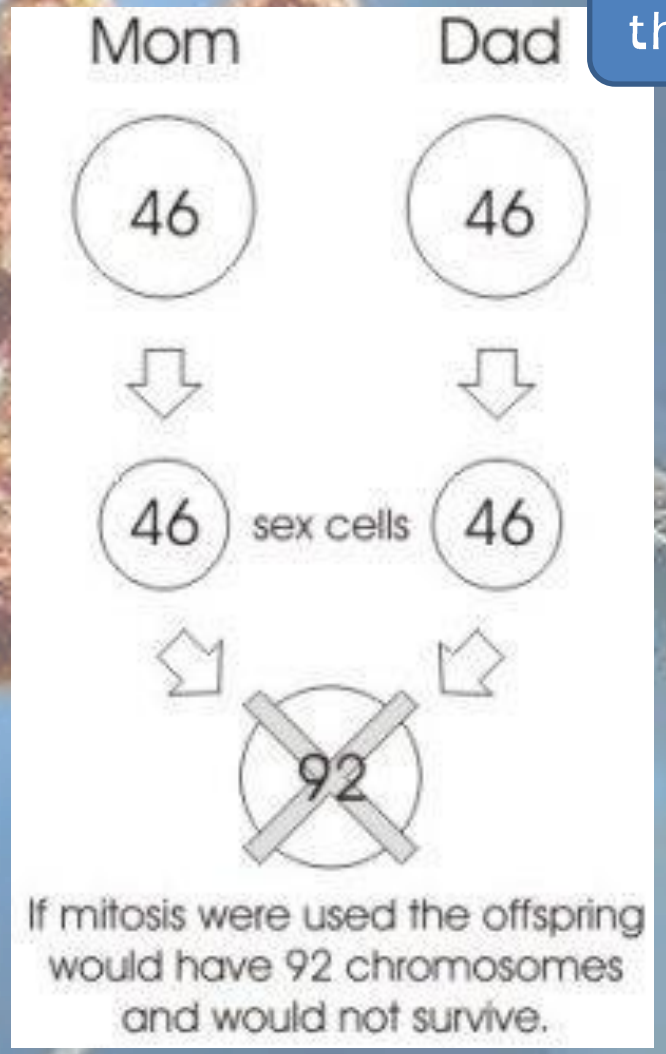
Why do we need Meiosis?

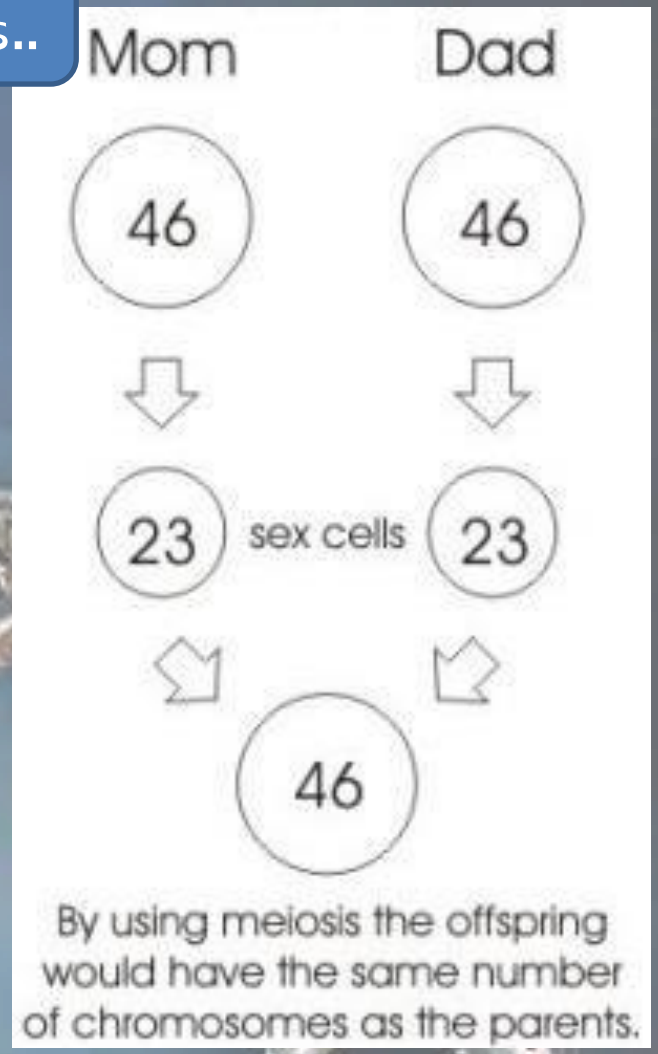
- From Greek μείωσις, meiosis, meaning "lessening“
- Each organism has a specific number of chormosomes in its body cells (somatic). Humans have 46
- If the chromosome number in each gamete isn’t reduced or ‘diminished,’ then the zygote would have double the chromosomes that it should!
- A process is therefore needed to reduce the chromosome number.
- Gametogenesis is that process. A specialized diploid cell undergoes meiosis resulting in haploid cells.

Meiosis – splitting genetic information

** In organisms that reproduce sexually there is a second type of cell division that is needed to ensure that the nucleus contains the correct number of chromosomes.

Draw this..

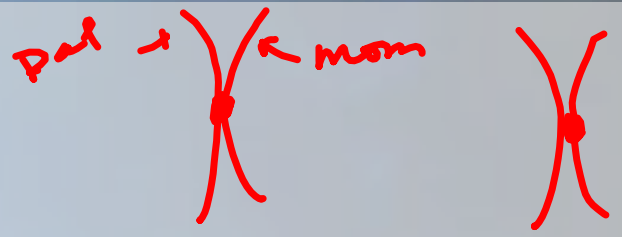




Major Events

Things to note…

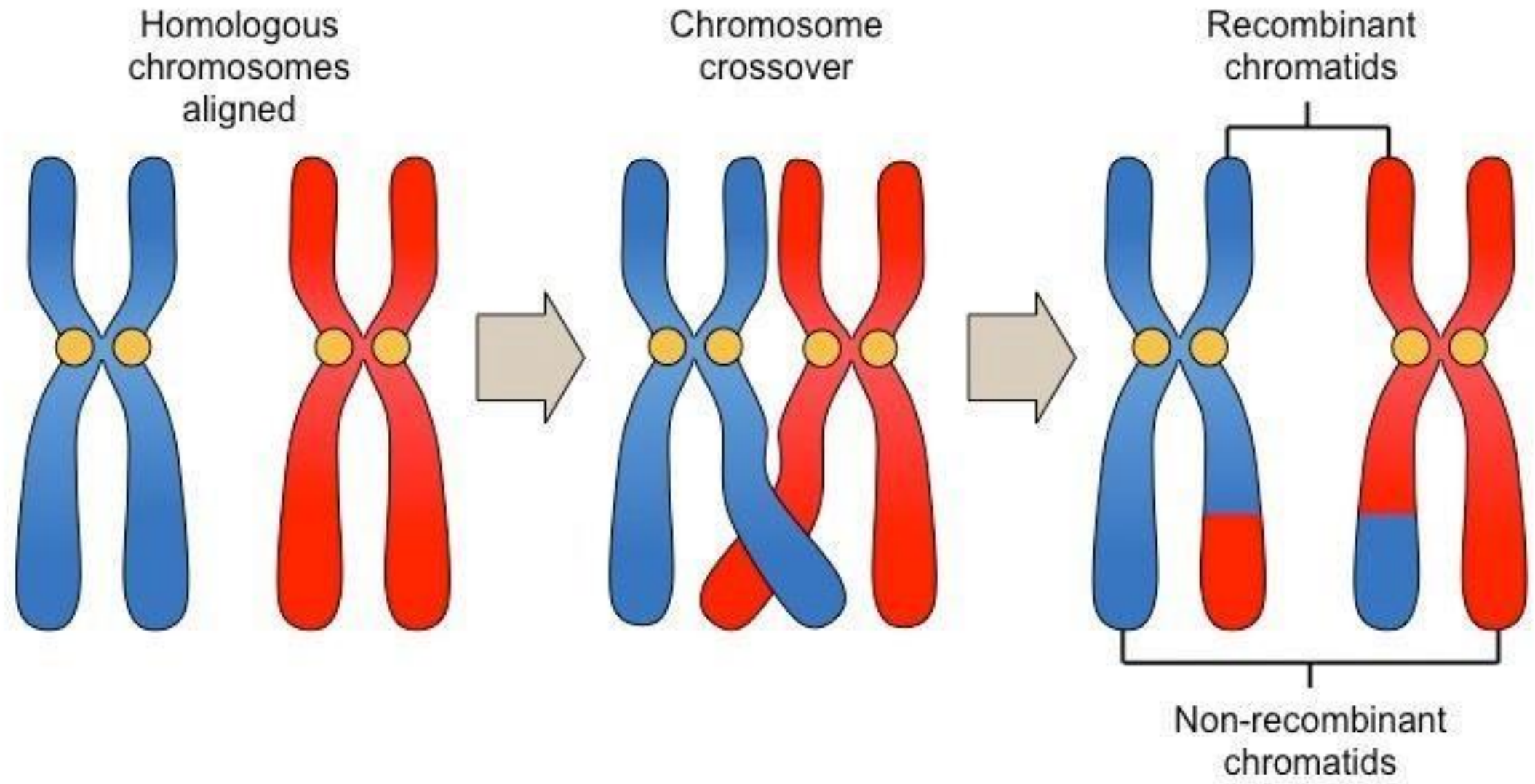
Crossing Over



- The most important event in terms of creating variation occurs in prophase I.
- Earlier you learned about homologous chromosomes. This is the point at which those chromosomes pair up in a process called synapsis.
- Each chromosome is made up of two identical sister chromatids. This tetrad consists of two homologous chromosomes (one from each parent) for a total of four chromatids.

Crossing Over

- Once synapsis has occurred, non-sister chromatids will 'crossover' and exchange genes.
- Remember, the genes are all the same on homologous chromosomes, so a gene for hair colour from one chromatid will exchange for the gene for hair colour on the other chromatid.


Homologous chromosomes aligned
Chromosome crossover
Recombinant chromatids
Non-recombinant chromatids

‘Allele’ vs the use of ‘Gene’

‘Allele’ vs the use of ‘Gene’

- So, an allele is one of the possible forms of a gene.
- Once the chromatids have completed the crossover, they are called recombinant chromatids, since they are now made up of genes combined from two different chromatids.
- The recombinant chromatids now contain genes from both original chromosomes. This random exchange of genes is a major source of variation among the chromatids.

‘Allele’ vs the use of ‘Gene’

- On average, it is estimated that two or three crossovers occur for each pair of homologous chromosomes.
- These crossovers can occur anywhere on the chromosomes, and the multiple crossovers can happen simultaneously.
- Think of all the possible combinations that can occur!

Independent Assortment

- After the crossover in prophase I, the tetrads align their centromeres along the middle of the cell during metaphase I.
- Spindle fibres from one pole attach to one of the homologous chromosomes, and fibres from the other pole attach to the other homologous chromosome.
- The homologous chromosomes are then pulled apart during anaphase Iand start to migrate to opposite poles.

Independent Assortment

- In the process or meiosis, there is another event that adds to the genetic variance.
- When the tetrads align in the centre, it is a random arrangement.
- A homologous chromosome could go to either pole depending on how it was arranged in metaphase I.
- This means that the chromosomes in each homologous pair are assorted independently from the other pairs.
- The result is that one pole could receive chromosomes from both the female and the male parent.
- **The process is random.

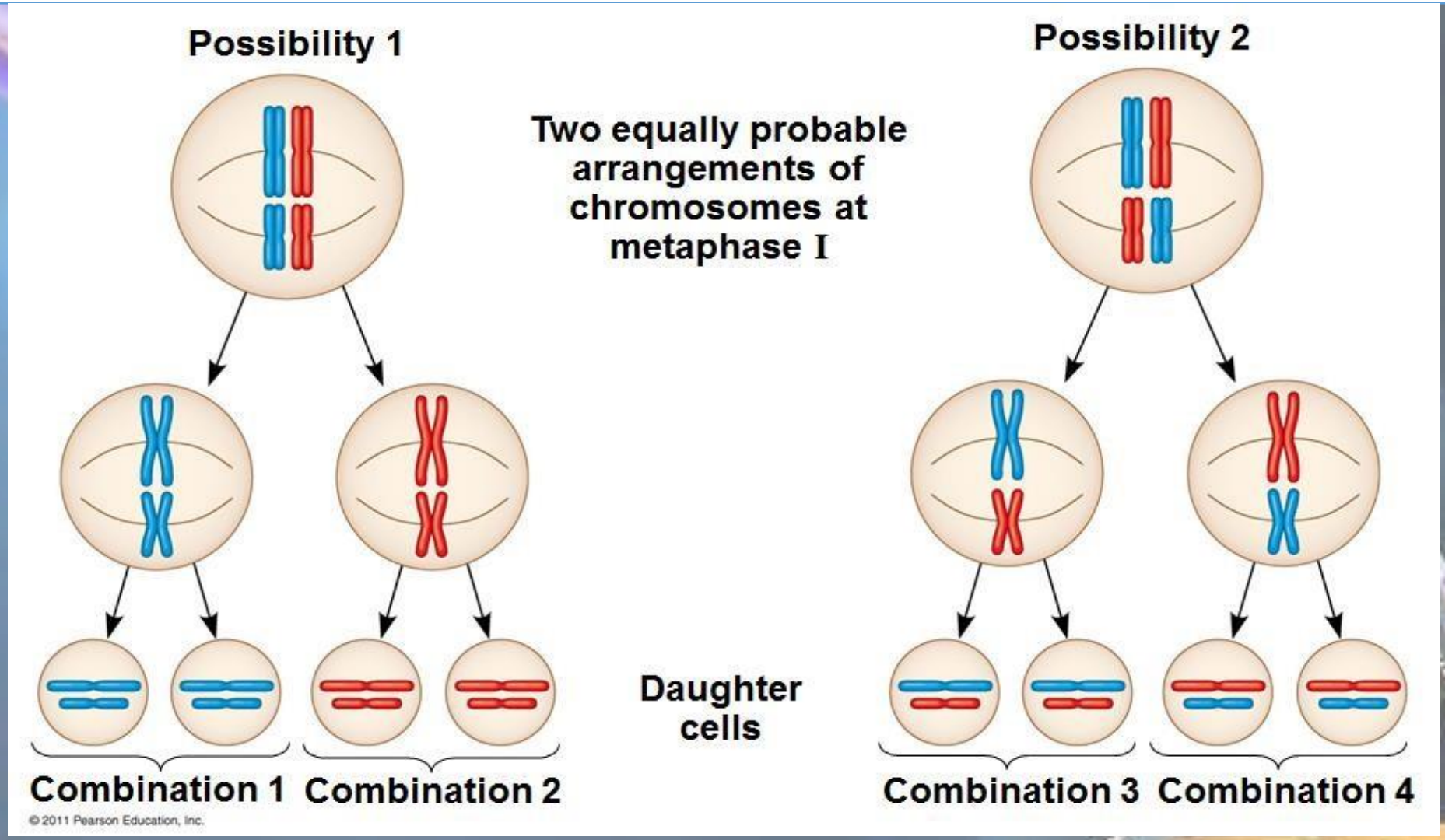
Independent Assortment

- The number of combinations that can result from this process by the end of meiosis Ⅱdepends on the number of chromosomes pairs that species has.
- Using the relation 2^n, where ‘n’ is the number of chromosomes pairs, you can determine the number of possible outcomes.

In Humans…

- Since humans have 23 chromosome pairs,
- that would be $2^{23} = 8\ 388\ 608$ possible combinations!
- Now, that number is just based on independent assortment.
- If you include all the variation that occurs during crossing over in prophase I, you will have an almost limitless number of possible combinations!
- You can now see why we all look different from one another, even when we have the same parents.

For example, if there were only two pairs of homologous chromosomes, you would have $2^2 = 4$ possible combinations after the homologous chromosomes are split during anaphase Ⅱ.

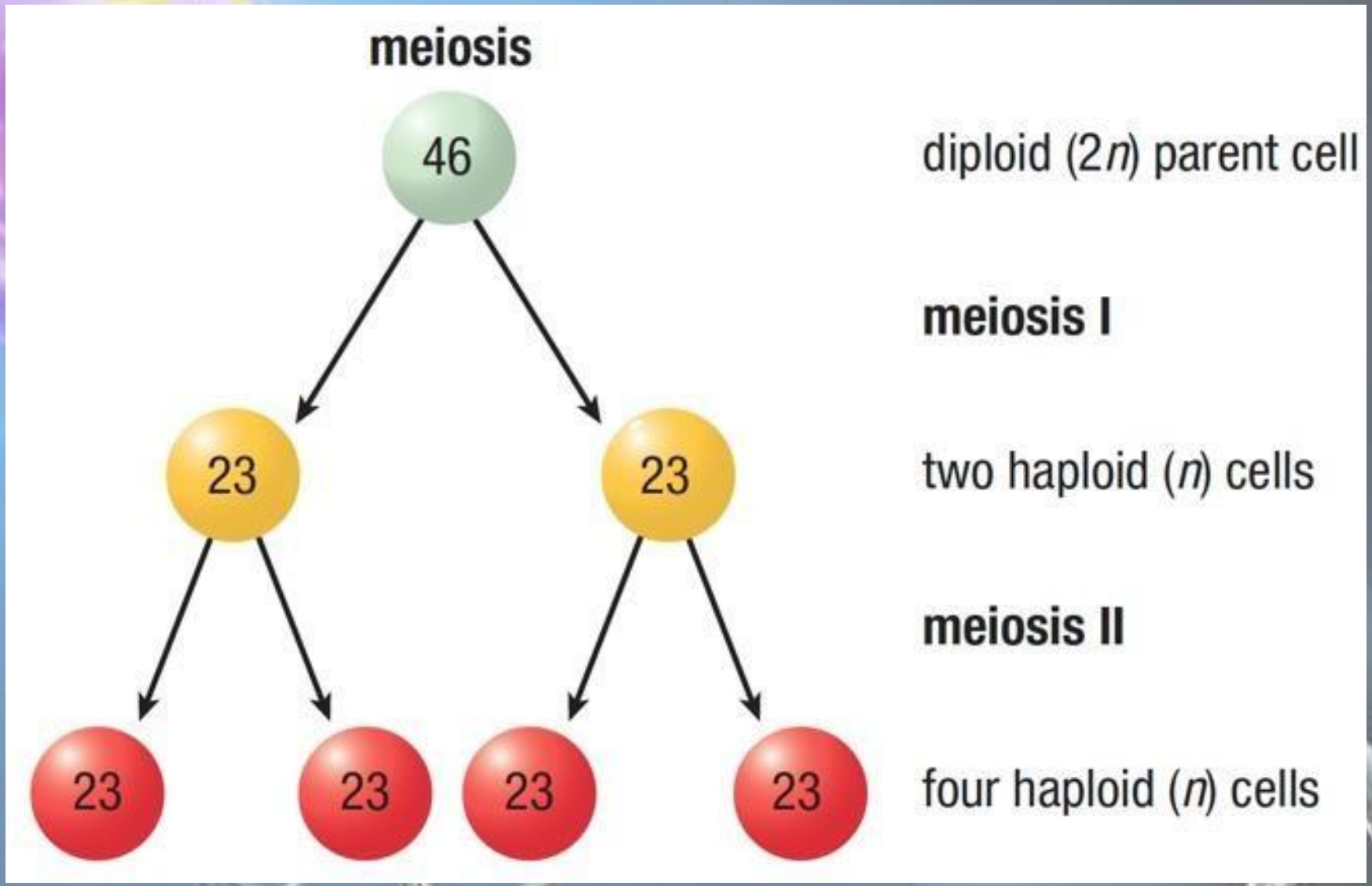


In Humans…

- One parent cell becomes four daughter cells, each being genetically different from the others and the original parent cell.
- And THAT is why sexual reproduction and the process of meiosis is a main driver of genetic variance within a population. You will see that another process, mutation, also plays a large role in genetic variation later in this unit.

Diploid to Haploid

- Although the idea of meiosis being a reductive process has been mentioned, it is very important that you remember that the end result of meiosis is four haploid cells.
- The diploid number drops to the haploid number of chromosomes at the end of meiosis I, and then continues in the haploid configuration all the way through meiosis II.



When the two gametes combine during fertilization, the zygote will be back to the diploid number of chromosomes.

Potential Complications

- Unfortunately, the process doesn't always go as planned.
- The goal is to have each of the four daughter cells contain the haploid number of chromosomes, but this isn't always the case.
- In rare cases, the chromosomes do not separate equally during anaphase I or anaphase II.

Gametogenesis

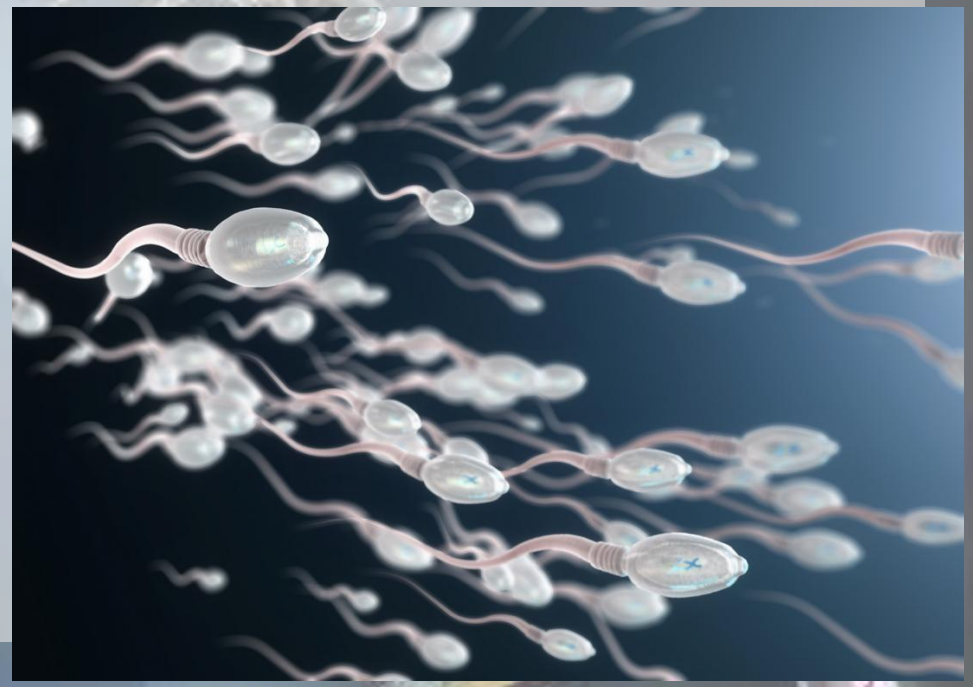
- The meiotic process that creates sperm and eggs (gametes)

Gametogenesis

- The formation of sperm cells in the male testes is called spermatogenesis
- The formation of eggs in the female ovaries is called oogenesis.
- The big difference is found between the final form of the male and female sex cells.

Spermatogenesis

- The sperm cells need to be highly motile, so they form whip-like tails to allow them to swim to the female egg.
- In addition, they are quite small, as this is an advantage when it comes to their ability to move quickly.

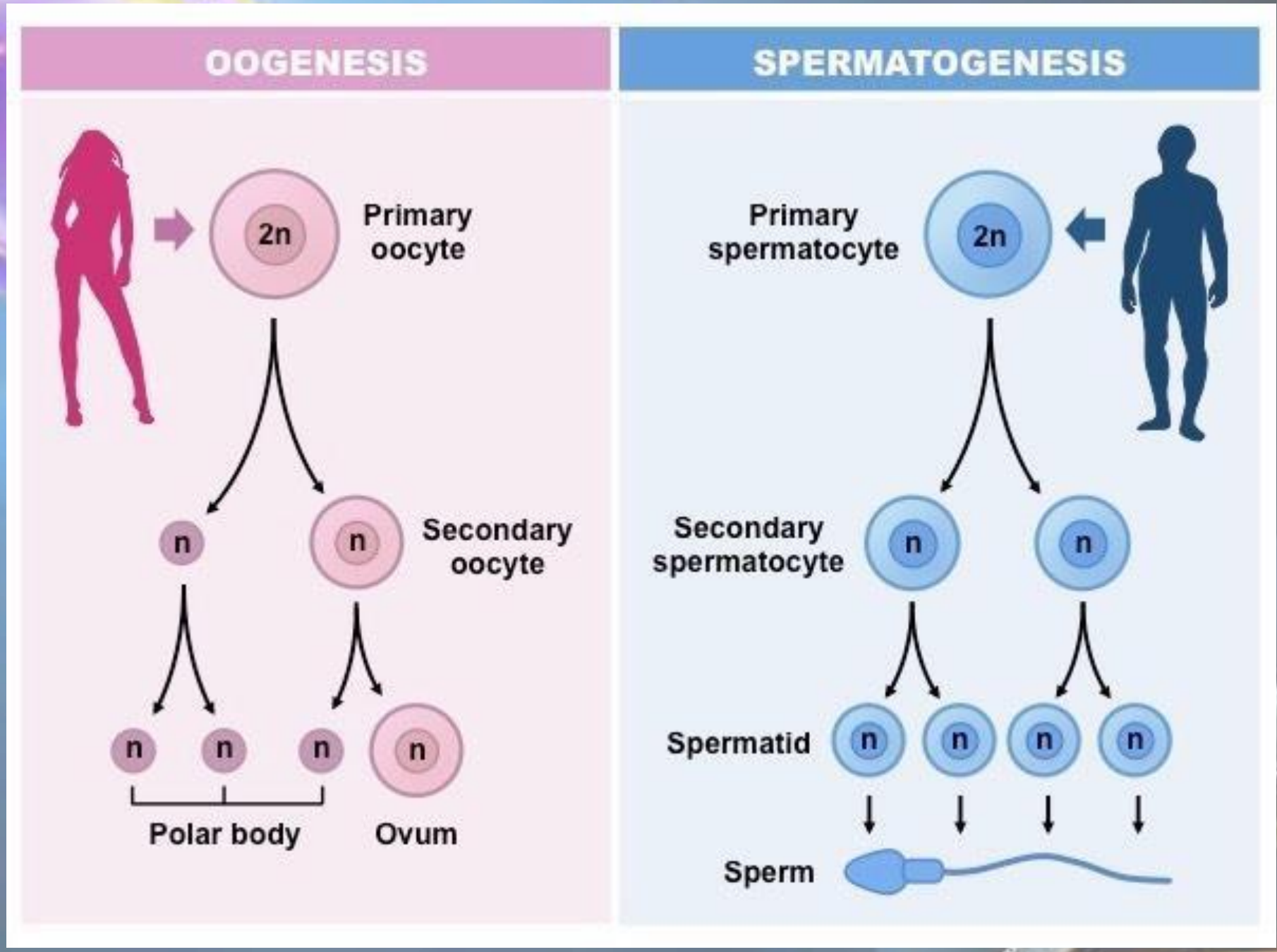


Oogenesis

- In the formation of egg cells, the majority of the cytoplasm and the organelles contained within the cytoplasm, goes to one of the sex cells.
- This one large sex cell now has the nutrients and cellular make-up available to support a developing zygote after fertilization.
- The three smaller cells, called polar bodies, die.
- This leaves just one egg or ovum available for fertilization.

Differences…

- Another major difference is the number produced. Females will release only one egg per month, while males will produce 1500 sperm cells a second!
- Why such a big difference in number? Only one egg and sperm is needed to create a zygote, but the race for the egg is very competitive, and very few sperm make it to the egg.
- If there were fewer sperm released, the probability of fertilization would drop dramatically.


OOGENESIS
SPERMATOGENESIS
2n
Primary oocyte
n
n
Secondary oocyte
n
n
n
n
Polar body
Ovum
Primary spermatocyte
2n
Secondary spermatocyte
n
n
Spermatid
n
n
n
n
Sperm