

Chapter 6

Are You Only as Smart as Your Genes?

Mendelian and Quantitative Genetics

6.1 The Inheritance of Traits

- Most children are similar to their parents
- Children tend to be similar to siblings
- Each child is a combination of parental traits
- The combination of paternal traits and maternal traits is unique for each individual child

The Inheritance of Traits

The human **life cycle**:

- **gametes** (a male **sperm** cell + a female **egg** cell) fuse during **fertilization** to form a single celled **zygote**, or embryo
- the embryo grows by cell division in mitosis
- the embryo grows into a child
- the child matures into an adult

The Inheritance of Traits

The human life cycle:

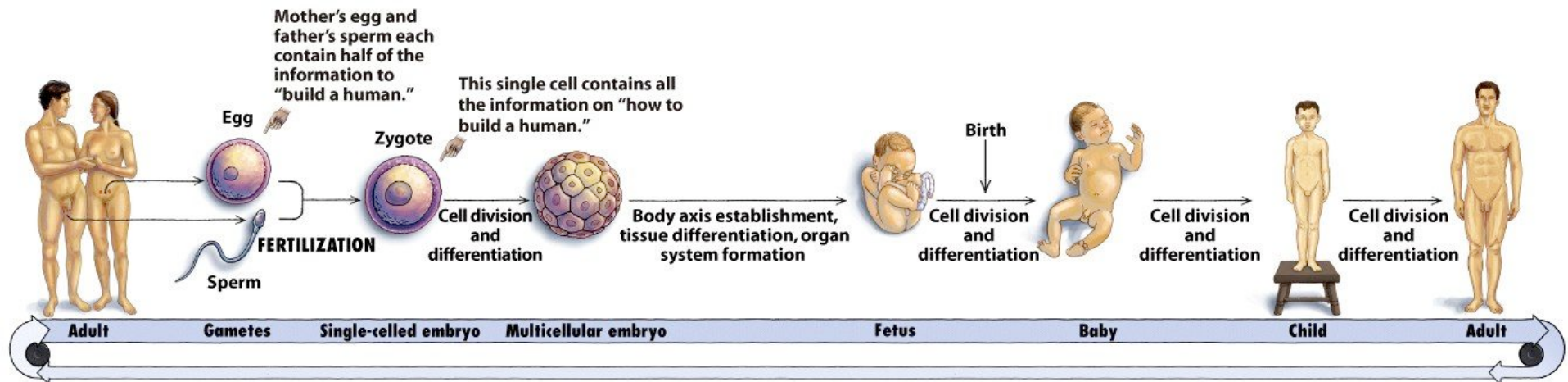


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Genes

- Genes are segments of DNA on chromosomes
 - that carry information about how to make proteins
 - Structural proteins
 - for things like hair and cell “skeletons”
 - Functional proteins
 - for things like digesting food and making the cell cycle go or stop

Genes

- All human cells have the all the same genes
 - Same 46 chromosomes in EVERY cell of an individual
- Only certain genes are active in a single cell type
 - Heart cells and eye cells have genes for the protein rhodopsin, which helps to detect light
 - Rhodopsin protein is only produced in eye cells, not heart cells

Genes and Chromosomes

- DNA is sort of like an instruction manual that shows how to build and maintain a living organism...

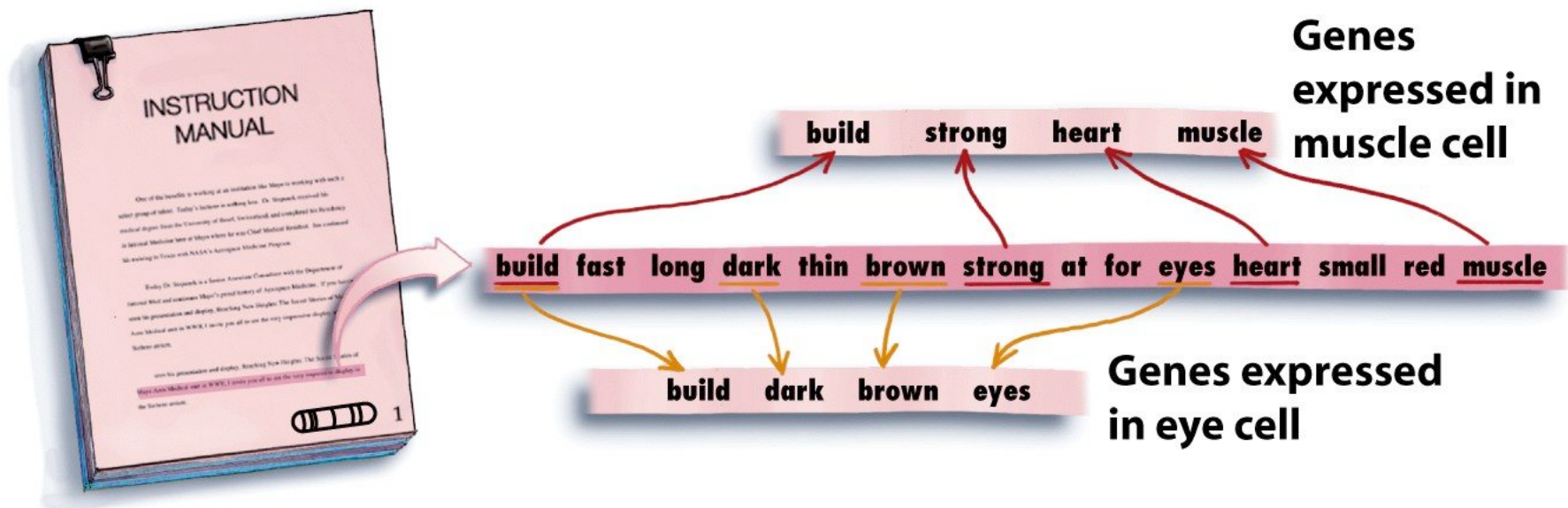


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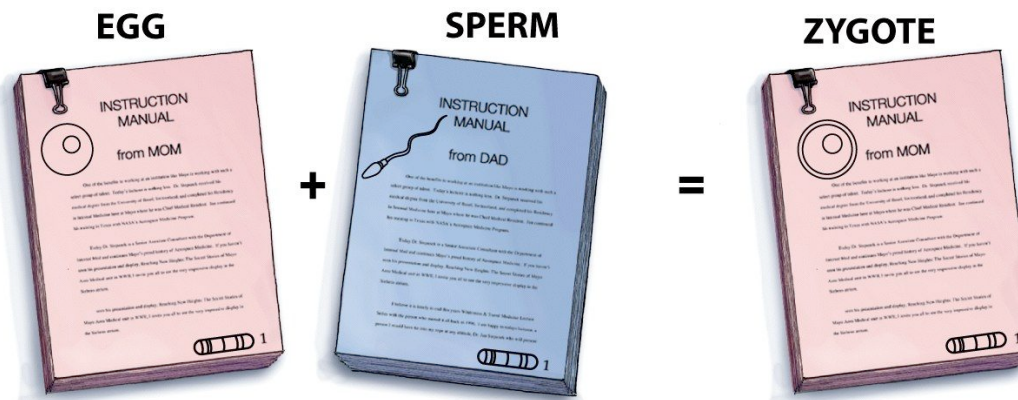
Genes Are on Chromosomes

- The genes are located on the chromosomes
- The number of chromosomes depends on the organism
 - Bacteria
 - one circular chromosome
 - Humans
 - 23 **homologous pairs** of linear chromosomes
 - 46 total chromosomes

Genes Are on Chromosomes

- Each of the 23 pairs of chromosomes
 - is a homologous (same) pair that carry the same gene
- For each homologous pair
 - one came from mom and the other from dad
 - Gene for earlobe shape from mom and gene for earlobe shape from dad

Both parents give a complete instruction manual to their offspring.



The 23 pages of each instruction manual are roughly equivalent to the 23 chromosomes in each egg and sperm.

The zygote has 46 pages equivalent to 46 chromosomes.

Gene Variation Is Caused by Mutation

- Genes on a homologous pair are the same, but the exact information may not be the same
 - Earlobe shape from mom is “attached”
 - Earlobe shape from dad is “detached”
- Same gene for earlobe shape, different versions or **alleles** of that same gene

Gene Variation Is Caused by Mutation

- Originally in evolution, all genes were the same
 - no different alleles
- Sometimes there are errors or **mutations in DNA**
- Mutations in genes can cause somewhat different proteins to be produced
 - Causing detached earlobes instead of attached earlobes
- These different gene versions create **alleles**

Mutations are errors in copying the instructions.

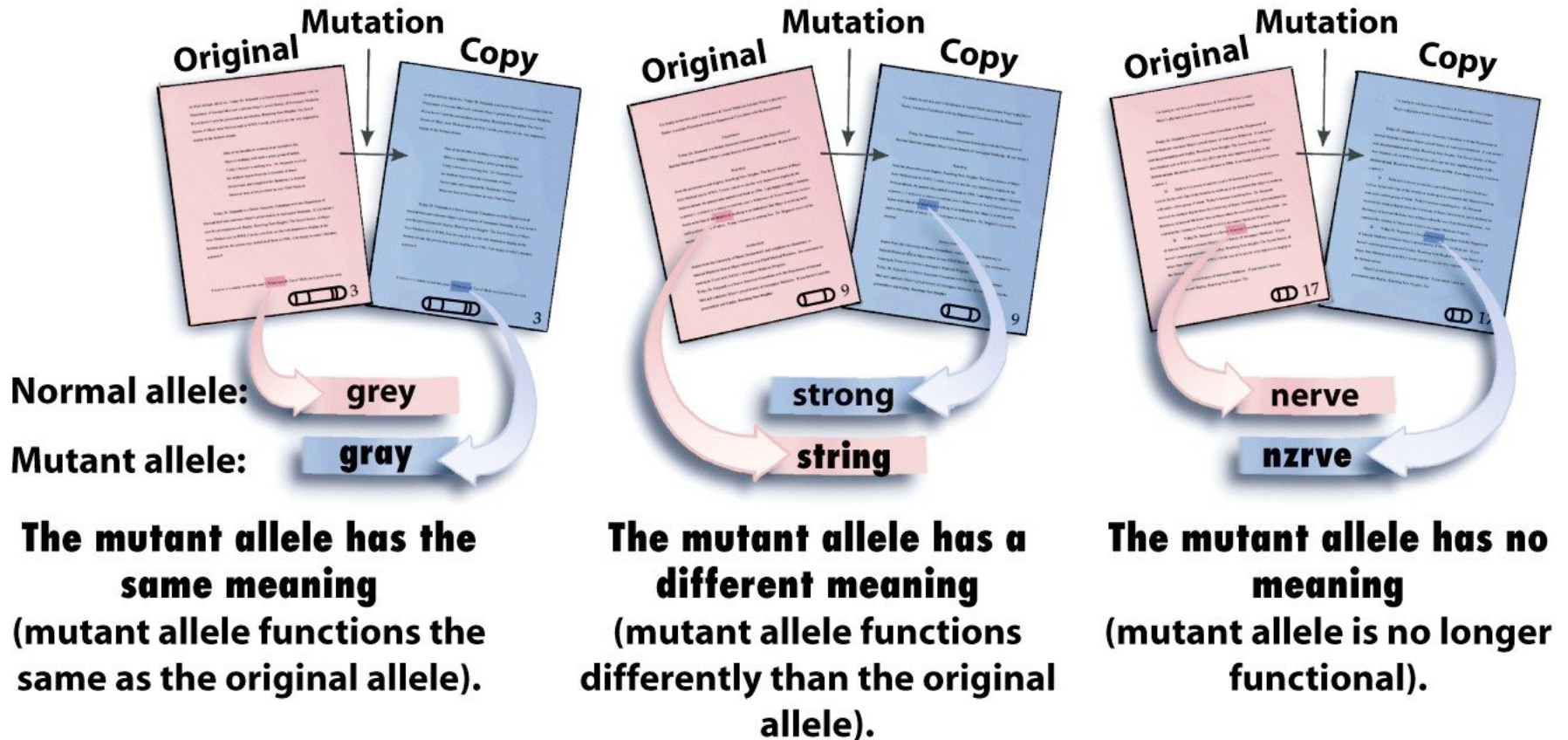


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Diversity in Offspring

- The combination of alleles from the parents
 - create the individual traits of each child
- Differing alleles from parents are the primary reason that non-identical twin siblings are not the same
 - Environment can also play a role

Diversity in Offspring

Non-identical twin siblings:

- The combination each individual receives depended on the gametes that were part of the fertilization event
 - Which egg and which sperm
- Remember:
 - that each gamete has only 1 copy of each homologous chromosome pair with one allele
 - Either the allele from that person's mom or dad
 - but not both
 - (normal cells have 2 homo chromos = 2 alleles)

Law of Segregation

- Separation of the 2 alleles of each gene during gamete formation is called the **law of segregation**
- When a gamete is formed
 - the 23 homologous pairs are separated (46 total chromos)
 - so that one of each pair goes into one gamete (23 chromos)
 - One chromo #1, one chromo #2, one chromo 3#, etc
 - and the other into another gamete (23 chromos)
- This results in gametes with only 23 chromosomes
 - 1 of each of the 23 homologous pairs
 - half of the 46 chromosomes
 - half of the alleles

Independent Assortment

- Due to **independent assortment**
 - parents contribute a unique subset of alleles to each of their non-identical twin offspring

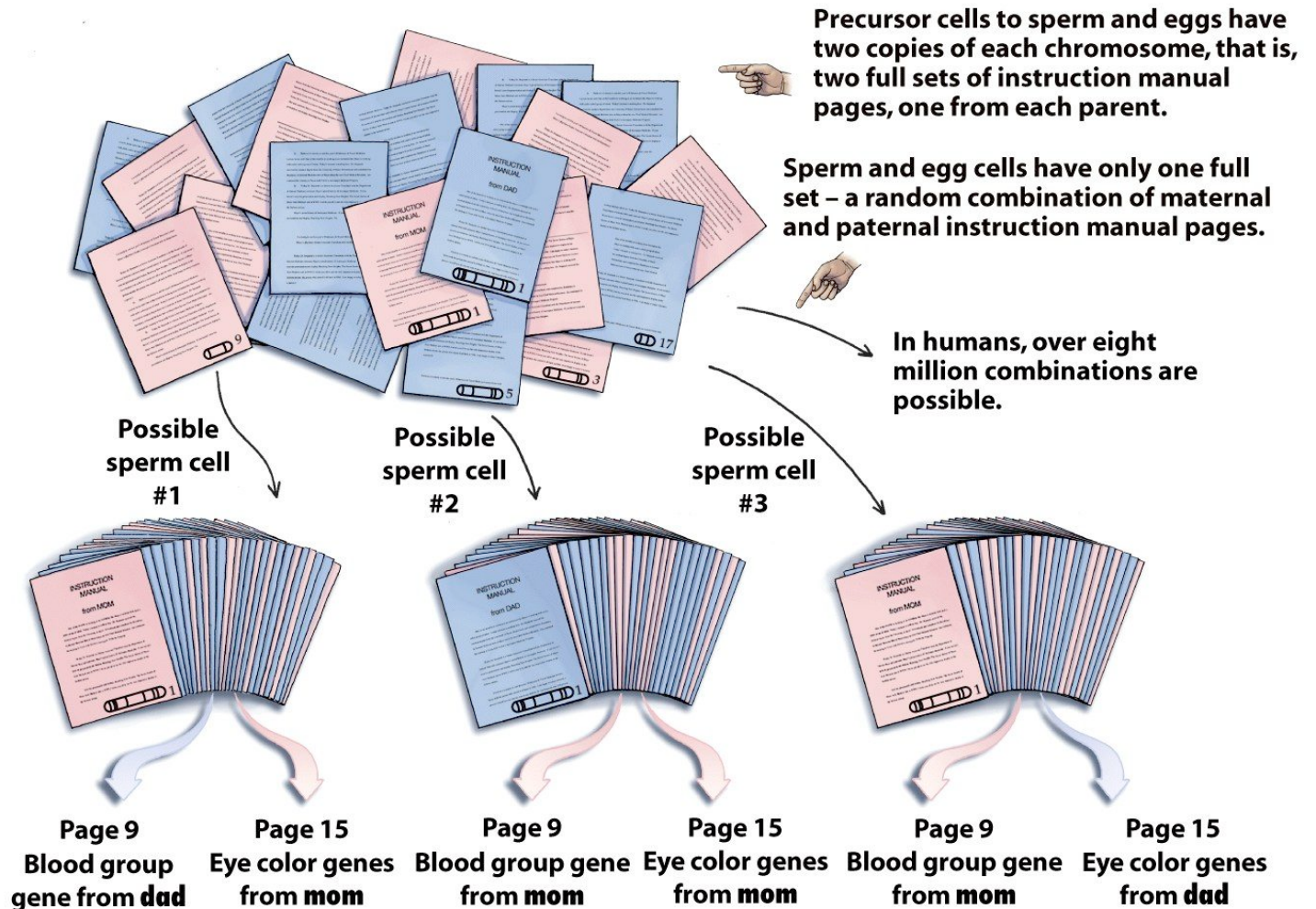


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Independent Assortment

Another independent assortment analogy:

- A pair of shoes is comparable to a homologous pair of chromosomes
 - The offspring shown to the right was made from one gamete with all R shoes but one L and a Gamete with all L shoes but one R
- Meiosis separates the members of one pair independently of other pairs
 - Some gametes may have all R or all L shoes
 - Others may have half R and Half L
 - Others may have 3/4 R and 1/4L
 - Etc
- Since each gamete is produced independently of the others
 - the combination of chromosomes (shoes) and corresponding genes is unique



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Diversity in Offspring

- That means a unique egg will be fertilized by a unique sperm to produce a unique child
- For each gene, there is a 50% chance of having the same allele as a sibling
- 50% chance of getting a R shoe or a L shoe
- If siblings both got the same shoes, they will be similar.
- If they both got the opposite shoes, they will be totally different

Diversity in Offspring

- There are 2^{23} combinations for the way the homologous chromosomes could line up and separate
 - This is more than 8 million combinations
- Gametes combine randomly
 - without regard to the alleles they carry in a process known as **random fertilization**
- You are one out of 64 trillion genetically different children that your parents could produce

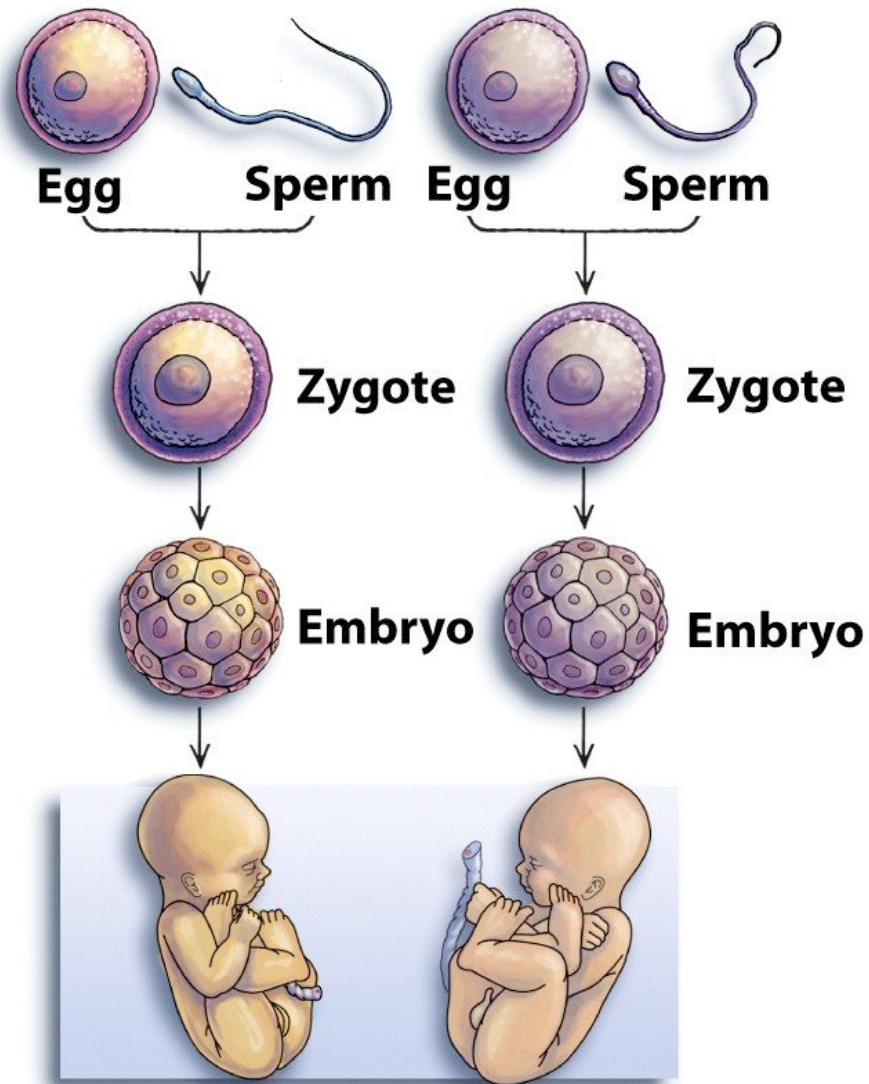
Diversity in Offspring

- The main ways sexually reproducing organisms result in offspring with unique combinations of alleles
 - Segregation of Alleles
 - Independent assortment of genes
 - Random fertilization
- These processes produce the genetic diversity of individuals found in humans
 - and all other sexually reproducing biological populations

Twins

- Fraternal (non-identical)
 - **Dizygotic**
 - two separate fertilized eggs at the same time
 - Not genetically the same
 - Same as non-twin siblings
 - Just happen to be in the uterus at the same time
 - Results from 2 ovulated eggs
 - Usually only one egg is ovulated per cycle
 - More than one egg ovulated per cycle can result from:
 - Genetic predisposition
 - Fertility drugs
 - First cycle after cessation of prolonged birth control pill use
 - Super-ovulation in women over 30

Dizygotic (fraternal) twins



**50% identical (no more similar than
siblings born at different times)**

Twins

- Identical
 - **monozygotic:**
 - one single fertilized egg that separates into two embryos
 - genetically the same
 - Identical alleles
 - A natural “clone”

Monozygotic (identical) twins

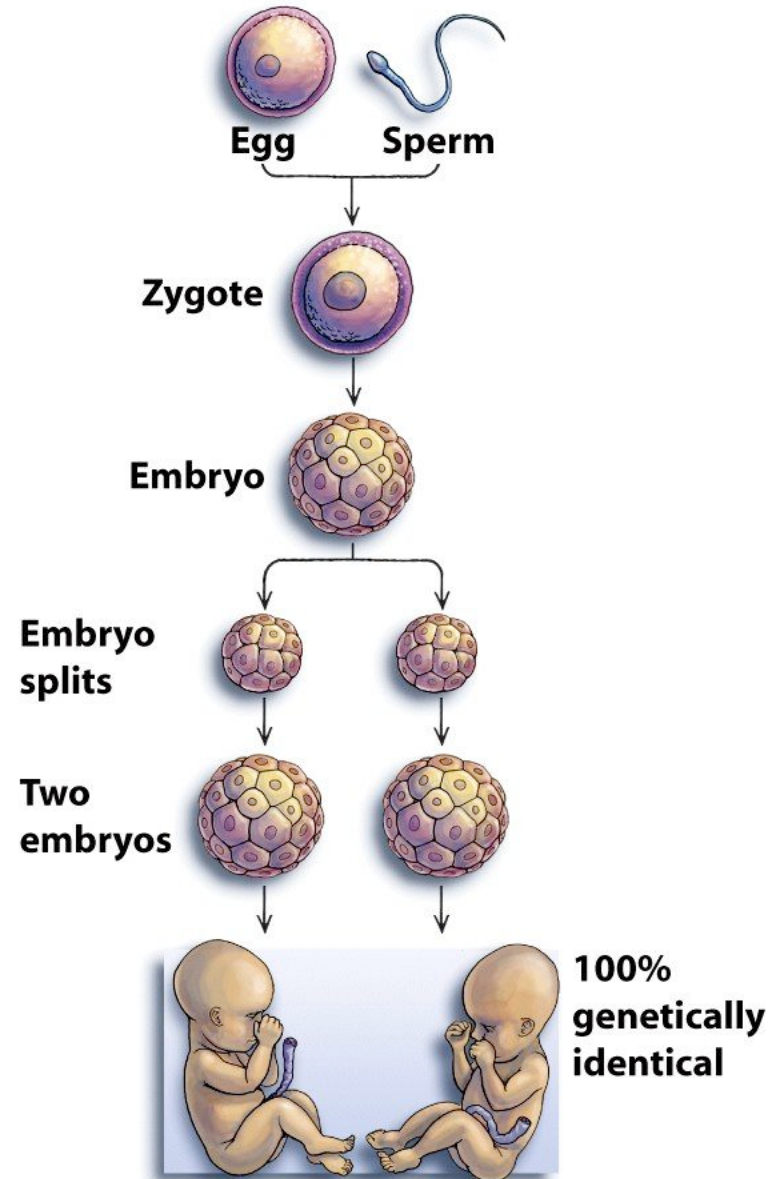


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