1. Eggs and sperm

Egg cells and sperm cells are different from all the other cells in the body. To start with, eggs are the largest type of human cell, and sperm are the smallest. More importantly, most body cells have a complete genome with two copies of every gene. Sex cells like eggs and sperm contain only one copy.

Egg and sperm cells are made through a special process called **meiosis**. This is similar to mitosis, the process of cell division, except for random recombination and dividing up genes. In **random recombination**, the genes inside a person's cells are mixed together so that the specific genes that end up in a sperm or egg are different in each sex cell. This is why every person is unique, even siblings with the exact same gene givers.* In **dividing up the genes** after random recombination, one random copy of each gene is divided into egg or sperm cells.

Just like different cell types go through mitosis at different rates, eggs and sperm also go through meiosis at different rates. Sperm cells take about 2 months to go through meiosis - though several hundred million sperm are typically made each day in a person with healthy functioning testes. Egg cells, on the other hand, can take 12-50 years to go through the process of meiosis! That is because the process of meiosis starts in the ovaries of a developing fetus and finishes just before ovulation, something that starts after puberty.

2. Egg development Before fertilization can occur, egg cells must mature. This happens in 3 steps:

Follicular phase
For most people who ovulate, hormones produced in the brain travel to the ovaries and stimulate the initial development of 15-20 eggs. Estrogen then limits the growth of all but one or two of those eggs to maturity in pockets called follicles.

Ovulatory phase
After one or more eggs mature, they are released by their follicle. This is called ovulation.

Luteal phase
After ovulation, the follicle that the mature egg was released from stimulates production of estrogen and progesterone. This increases the thickness of the uterine lining, called the endometrium. This is what is released during menstruation if a fertilized egg does not implant during the luteal phase.

3. Fertilization and the zygote

After an egg is mature, it can be fertilized by a sperm cell. Eggs and sperm both contain half of the genetic material in a human body cell. Once they combine, a **zygote** is created - a single fertilized egg with a complete and unique human genome.

When a sperm cell successfully merges with an egg cell, the cortical reaction occurs, which makes it impossible for other sperm to fertilize the same egg. This is important because the human genome has two copies of each gene - one from an egg and one from a sperm.

Having more than two copies of all genes would make cell division impossible, though occasionally an extra chromosome, or packet of genes, will end up in a fertilized egg! This can lead to conditions like Down Syndrome or Klinefelter Syndrome, which vary in how much they impact individuals who carry those extra copies.

4. Morula - like a “little raspberry”

Once an egg is fertilized, it starts to divide - really fast! Mitosis begins and the zygote becomes a morula, which is a ball of cells that some people think looks like a little raspberry. Every cell has an identical genome to the original zygote.

A morula can develop in a variety of settings, including outside the human body. Fertilization inside the body typically happens inside a fallopian tube that connects an ovary to the uterus. When fertilization happens in a lab, it is called “in vitro fertilization,” or IVF. The longest amount of time a morula has lived in a lab is 13 days - that is because of an international rule that says that you cannot allow a human to develop for longer than 14 days in a lab.

Some people believe that studying fetal development beyond 14 days should be legal, while others do not. Until 2017, the longest a morula had survived in a lab was 8 days, so it was never an issue. Some scientists believe that allowing morulas to develop longer outside the body could develop important medicine related to pregnancy loss. Others argue that allowing the fetus to develop any longer would be immoral treatment of human life. Currently, the 14 day rule is still the norm around the world for ethical research on fertilized eggs.

5. Blastocyte implantation & the placenta

After the morula has grown for several days, it is ready to implant on the endometrium, the wall of the uterus. This implantation changes the morula into a blastocyte and is an important stage in pregnancy.

Once a blastocyte is securely attached to the endometrium, it grows into a fetus and a placenta. The fetus eventually develops into a baby over the course of about 40 weeks. The placenta is a protective structure that carries blood to and from the fetus, bringing oxygen and glucose from the carrier's bloodstream and carrying away waste via the umbilical cord.

The placenta is originally made of cells from the blastocyte, but it also contains cells from the person carrying the pregnancy. It's a pretty unique structure biologically. In addition to carrying blood to and from the growing fetus, it also filters anything that might be dangerous to its development, produces hormones that keep the fetus developing normally, and contributes antibodies towards the end of pregnancy.

6. Embryonic layers

Around week 3 of development comes gastrulation, when cells start to differentiate into different future parts of the body. These cells are considered "stem cells," since they can become a large variety of different tissues. Once they specialize into those tissues, they will be fixed as those cell types.

The **ectoderm** is a layer of cells that will develop into epidermis (outer layer of skin), hair, nails, brain, spinal cord, and the nervous system.
The **mesoderm** is a layer of cells that will develop into muscle, bone, connective tissue, kidneys, gonads, and the circulatory system.
The **endoderm** is a layer of cells that will become the lining of the digestive tract, stomach, colon, liver, pancreas, bladder, and lungs.

Over the coming weeks, the developing fetus will look more and more like a human, differentiating the head, arms, legs, and inner organs.

7. Birth

Most babies are ready to be born after 40 weeks of pregnancy, though there is a wide range in this timeframe. Increasing technology has allowed premature babies - those born 3 weeks or more before the original due date - to thrive. The shortest term a baby has ever had inside a uterus and survived is 21 weeks, 5 days - that baby is now a healthy 30-year-old man. Most births fall into one of these two categories:

Cesarean section (or "C section") - A surgical procedure where a baby and their placenta are removed from the uterus through an opening in the abdomen. Some C sections are planned in advance, while others are a result of complications during vaginal birth.

Vaginal birth - A baby and a placenta leave the body through the vaginal canal. Some people have vaginal birth in a pool of water that supports the body; since the baby is still connected to the blood stream of the pregnant person, they do not need to breathe air yet. Some people take medication for pain during a vaginal birth and some people don't. If a pregnancy is more than 3 weeks late, a doctor may induce labor to start the process of a vaginal birth to make sure that no complications come from a late pregnancy.

*"Gene givers," "spawners," and "storks" are all different words we came up with as a class for the people who make the egg and sperm that become a new human. That's because right now, there is no excellent word in English to describe that specific relationship. What word(s) would *you* like to use?