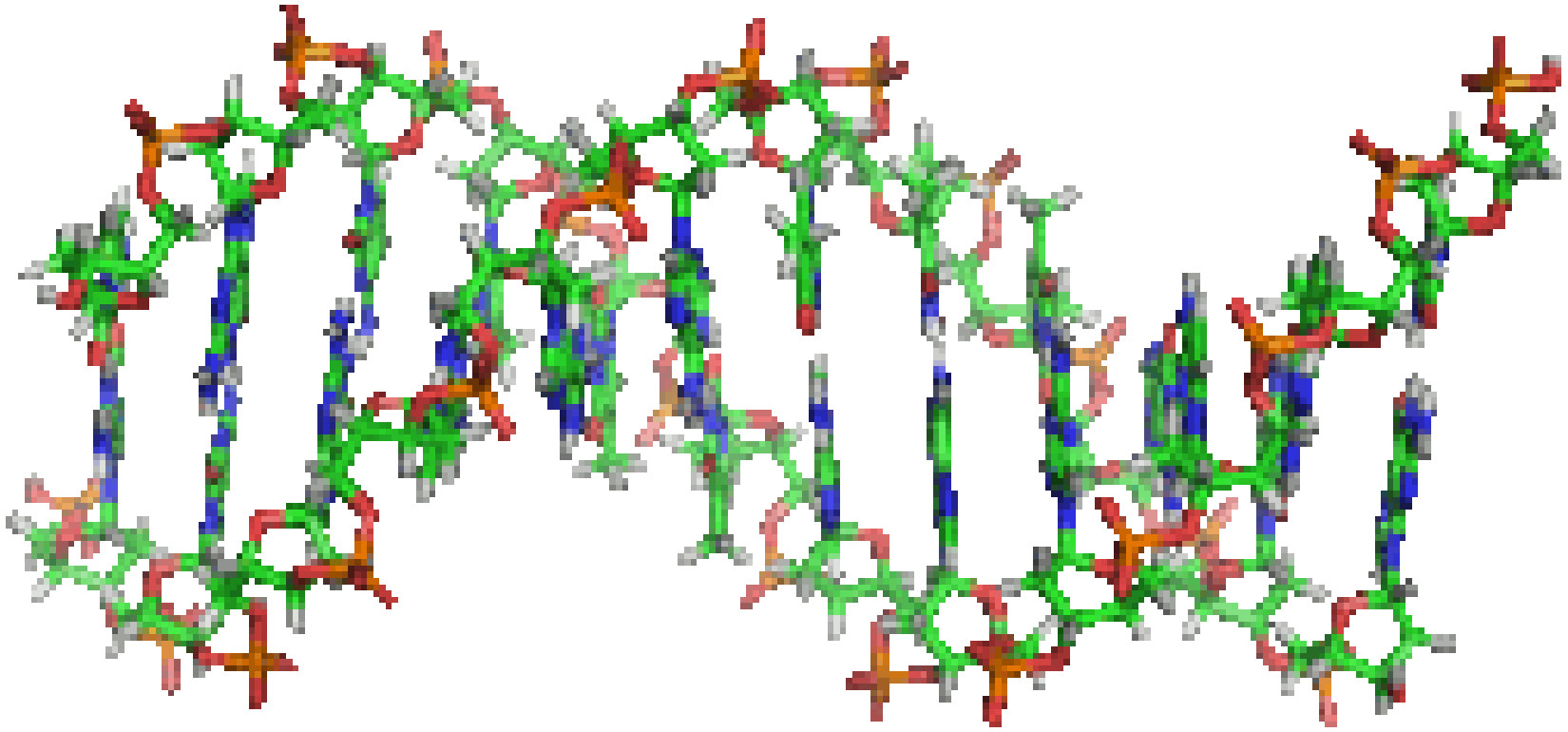
DNA – THE MOLECULE OF LIFE !



COMPILED BY HOWIE BAUM

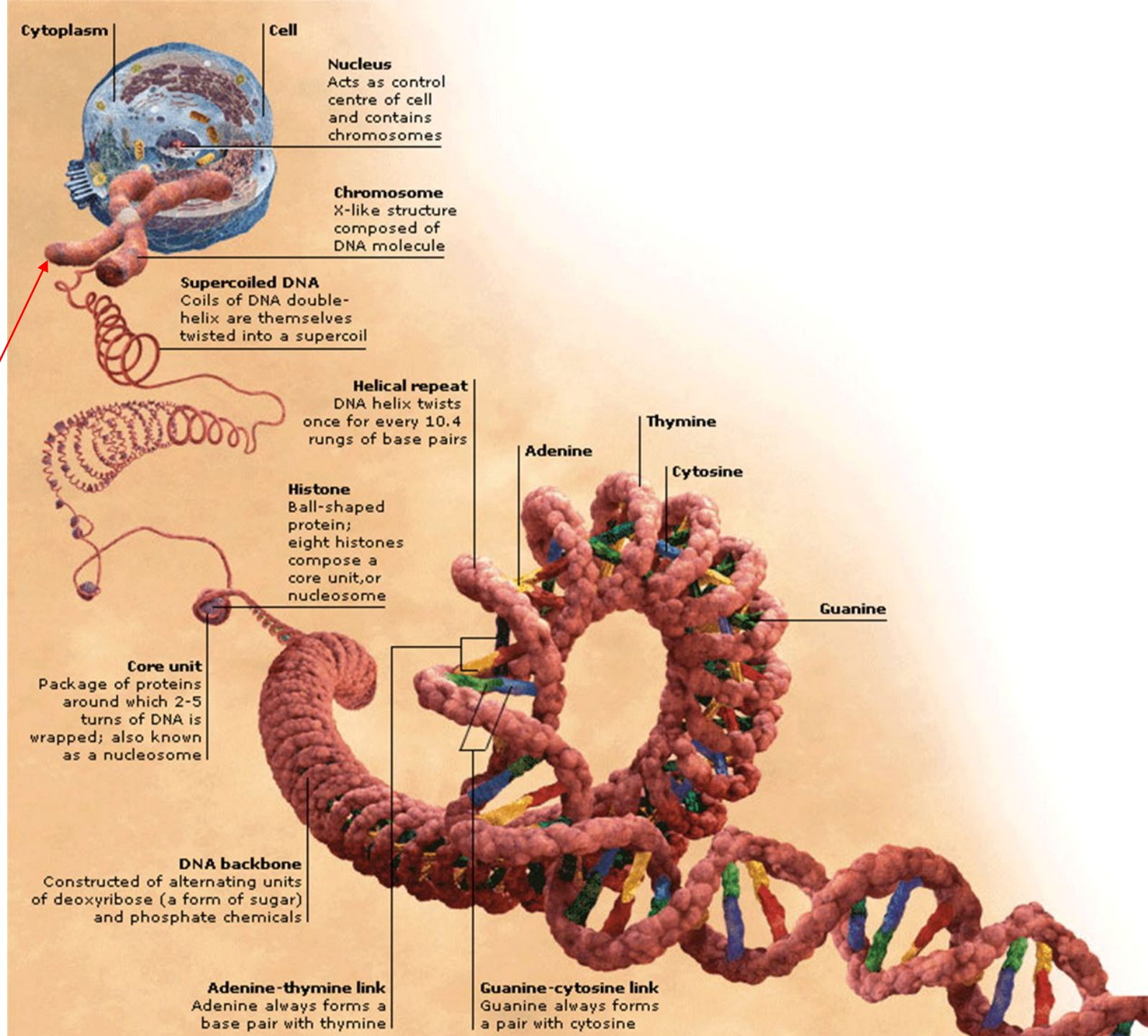
DNA

Often referred to as the molecule of life, DNA (deoxyribonucleic acid) is found in almost all living things.

It acts as a type of chemical code that contains instructions, known as genes, for how the body and all its different parts grow, develop, function, and maintain themselves.

It is tightly packaged into 46 X-shaped elements called chromosomes, which are situated in the cell's nucleus.

DNA's enormous list of instructions takes the form of long, thin molecules, one per chromosome, each taking the shape of a double-helix.



GENETIC CODE

The double helix of DNA consists of two corkscrew-like backbones joined by cross-rungs, which are pairs of chemical bases, of four kinds,

Adenine (A)

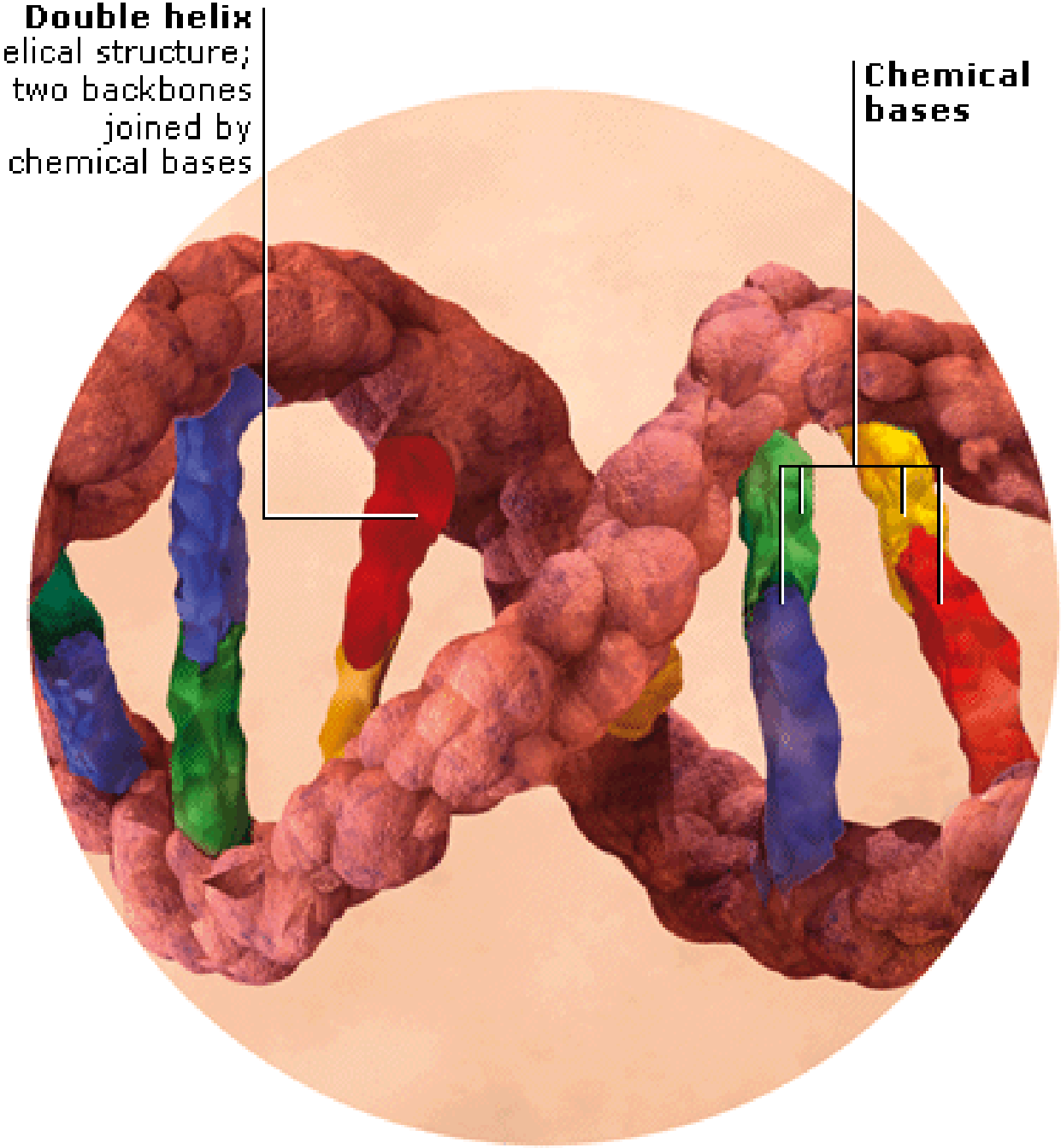
Thymine (T)

Guanine (G)

Cytosine (C).

The bases always pair in a specific way - A to T and G to C and are called a base pair.

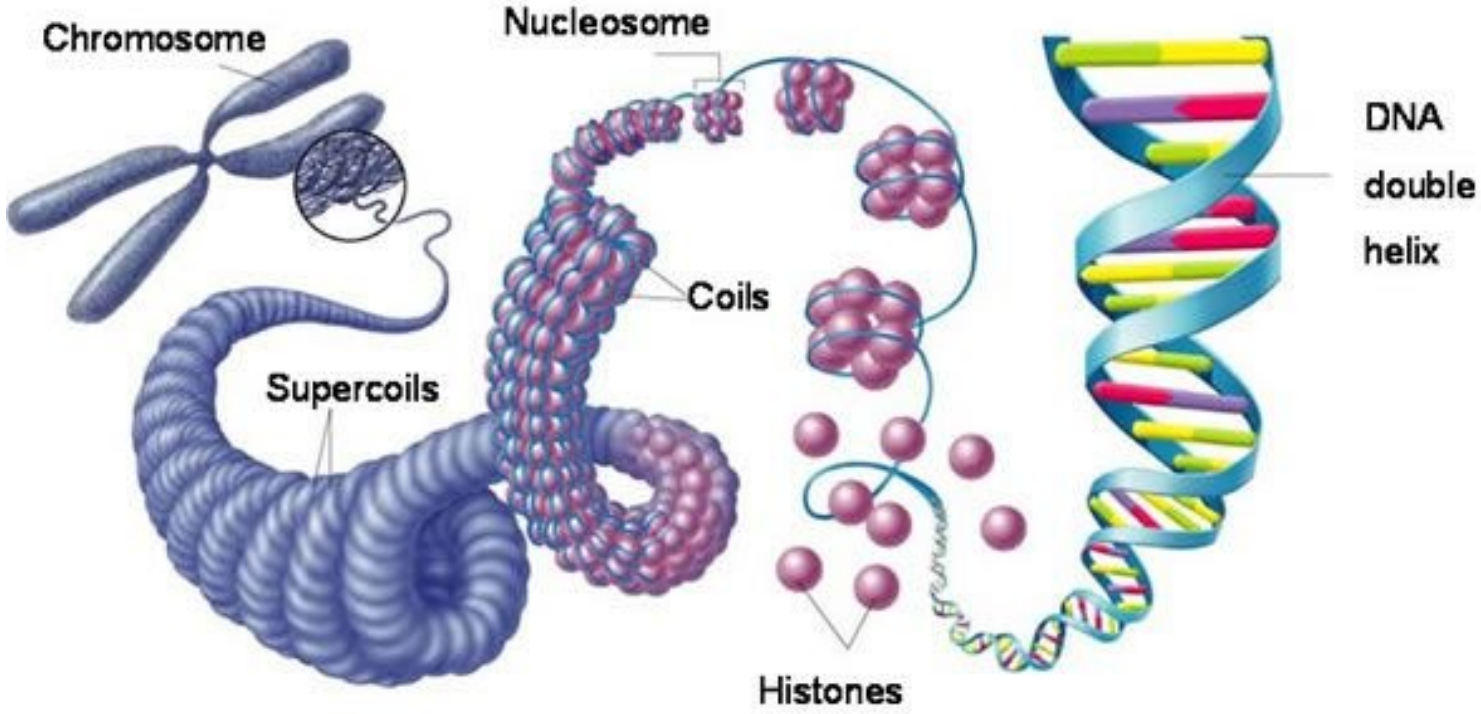
There are almost 300 billion base pairs in each strand of DNA !



DNA INTO CHROMOSOMES AND INTO THE EGG AND SPERM, TO MAKE YOU AND ME !!

Before talking about the amazing process of Human Reproduction, it is helpful to understand the very cool process of how DNA is made and coiled into Chromosomes that are the basic part of the Genetic information from the Male Sperm and the Female egg which create a new Life, when they combine with each other.

Cell division is the mechanism by which DNA is passed from one generation of cells to the next and ultimately, from parent organisms to their offspring.



CHROMOSOMES – STATED CLEARLY https://www.youtube.com/watch?v=IePMXxQ-KWY&t=28s 5 MINUTES

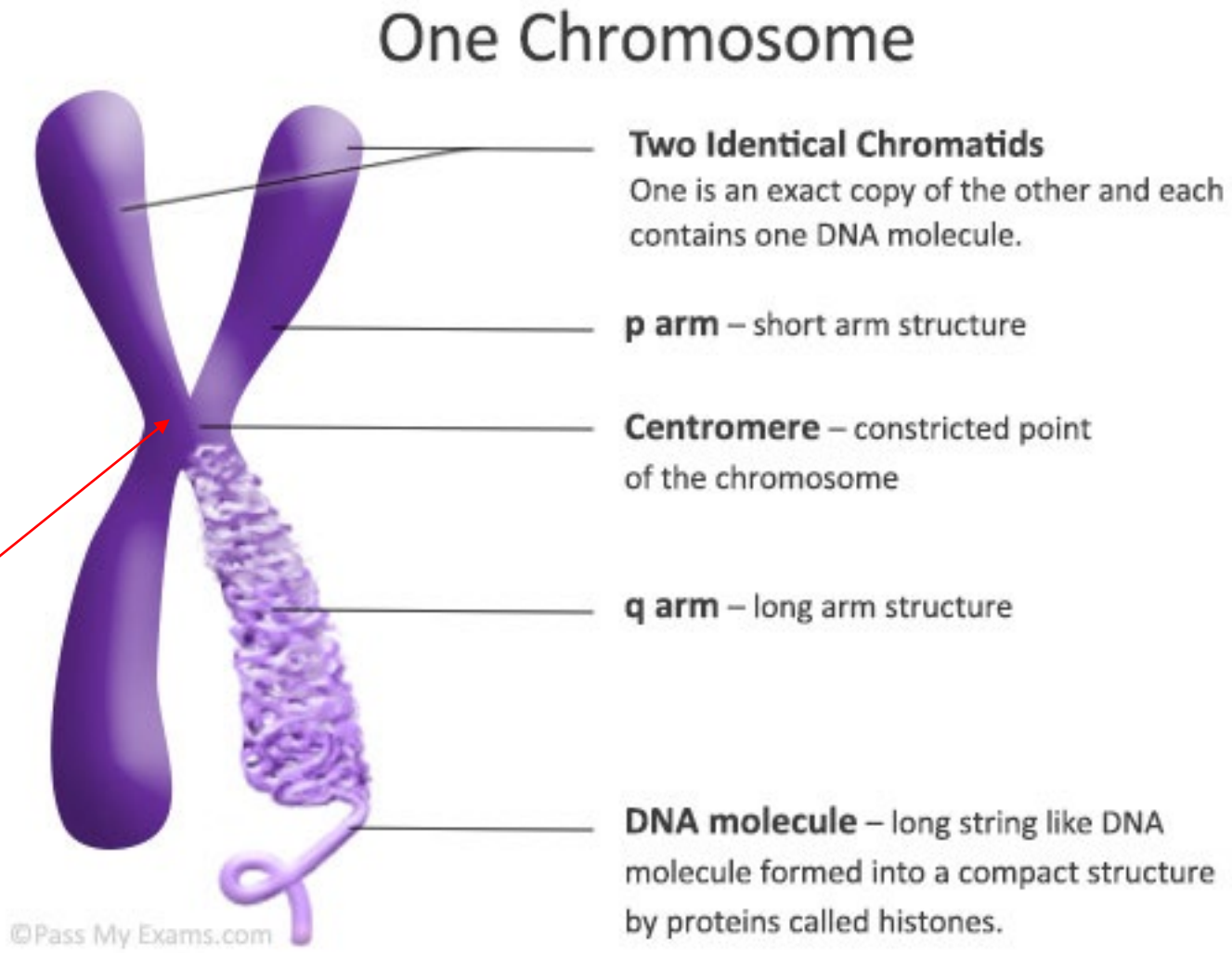
Most of the time, DNA looks like a tangled ball of yarn or big bowl of noodles— diffuse, disordered, chaotic.

This is the time that copies of the long DNA strand is copied to make a perfect duplicate.

But that messiness poses a problem during mitosis, when the cell has to make a copy of its genetic material and divide in two.

In preparation, it tidies up by packing the DNA into dense, sausage-like rods, called Chromatids, with 2 of them together to make up the chromosomes' most familiar form, in the shape of an X.

The chromosome is made of 2 identical daughter chromatids that contain the exactly copied strands of the DNA and are bonded at the center with a part called a Centromere.



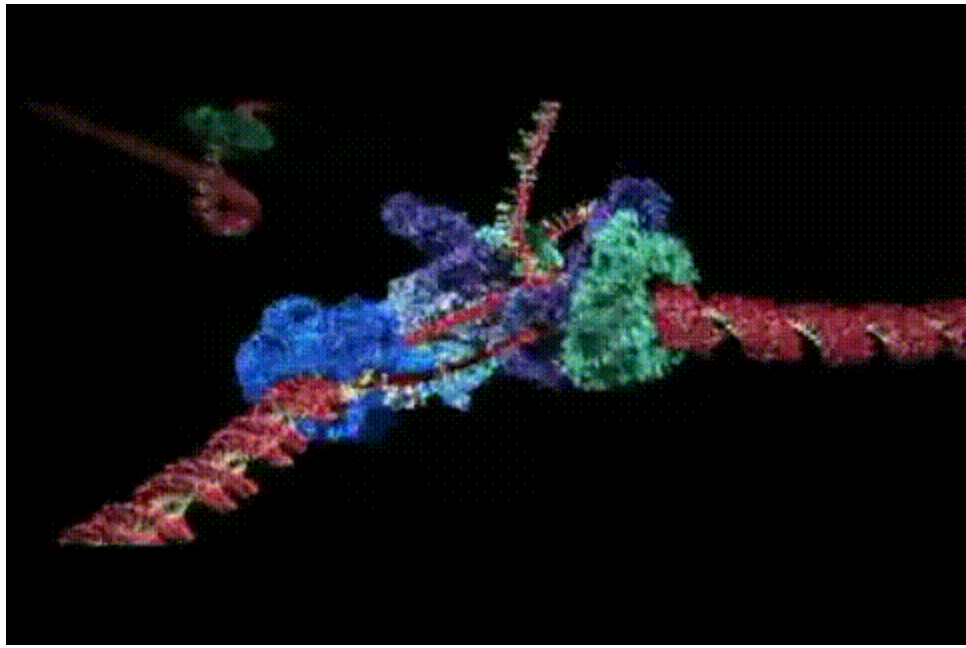
https://www.youtube.com/watch?v=gbSIBhFwQ4s
GO TO 1.12 MINUTES

DNA REPLICATION IS PROBABLY ONE OF THE MOST AMAZING TRICKS THAT DNA DOES.

- Each cell contains all the DNA you need to make the other cells.
- We start out from a single cell and we end up with trillions of cells.
- During that process of cell division, all the information in a cell has to be copied, and copied perfectly.
- **There are almost three billion base pairs of DNA to be copied which is done by molecules called polymerases specifically dedicated to just copying DNA.**
- **This takes several hours of just pure copying time**.
- At the end of this process, the cell actually has twice the amount of DNA that it needs
- It can then divide and parcel this DNA into the daughter cell, so that the daughter cell and the parental cell are absolutely, genetically identical.

The body is making 96 million cells every minute !

Think of the miracle going on inside each of these cells in us, that have a miniature manufacturing process going on to create a duplicate copy of new DNA for each cell !



https://www.youtube.com/watch?v=bee6PWUgPo8

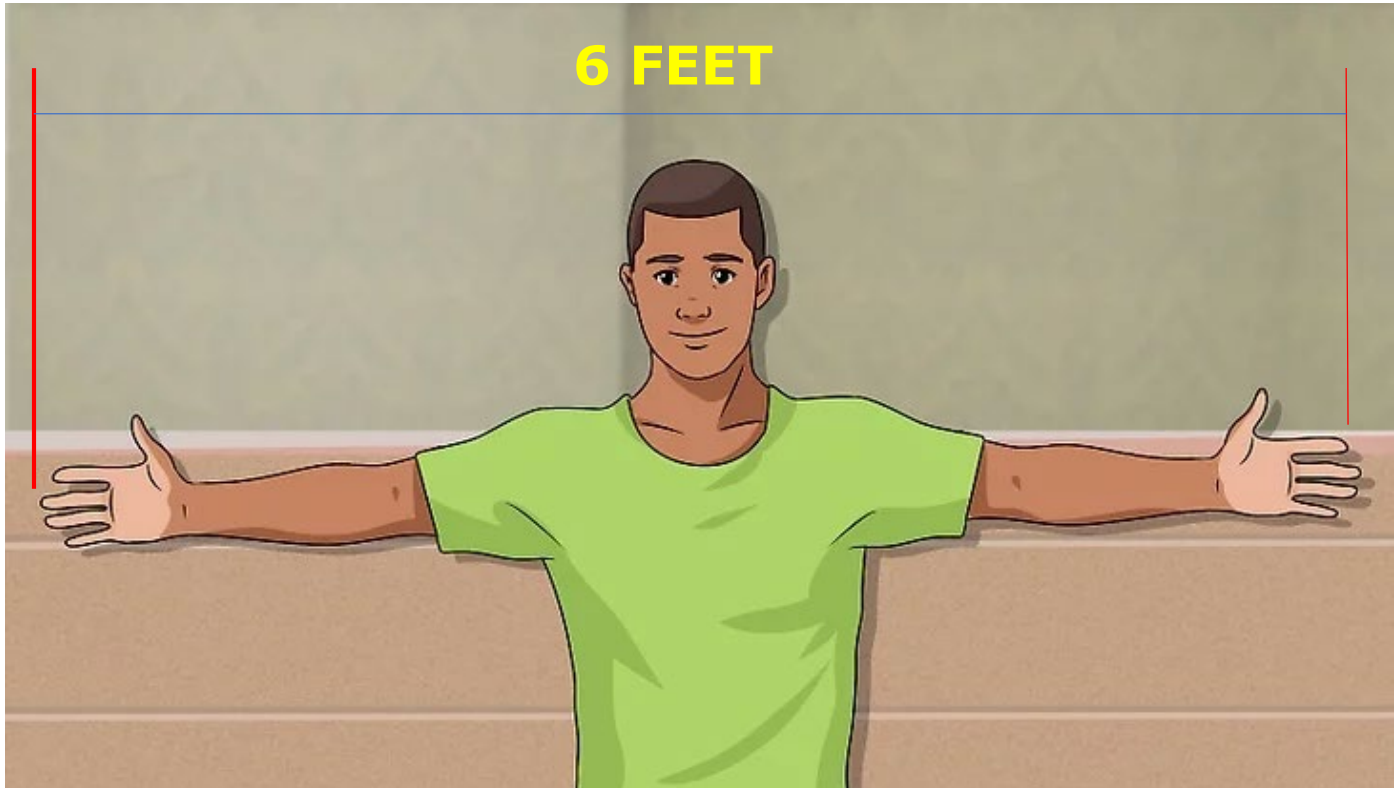
ANIMATION BY DREW BERRY – SEE PAGE 19

This extra coiling process allows the 3 billion base pairs in each cell to fit into a space just **6 microns** (6 millionths of a meter) across, which is about .00004 (4 ten-thousandths) of an inch.

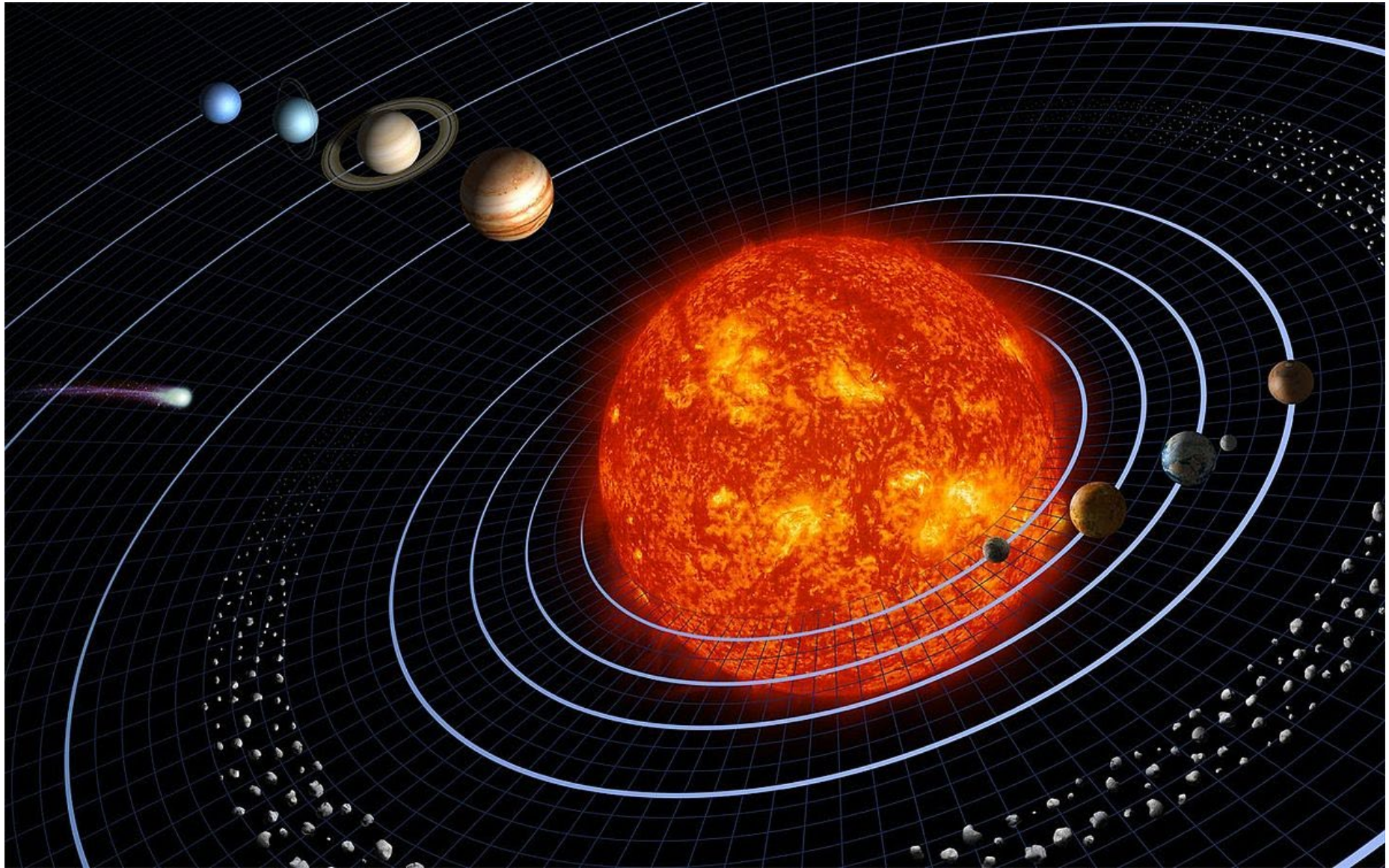
This is geometrically equivalent to packing 40 kilometers (24 miles) of extremely fine thread into a tennis ball!

For size comparison, a human red blood cell is about **5 microns** across. A human hair is about **75 microns** across

If you stretched the DNA in one cell all the way out, it would be about 2 meters (over 6 feet) long !!



IF ALL OF THE DNA IN ALL OF YOUR CELLS WERE STRETCHED OUT AND PUT TOGETHER, IT WOULD BE ABOUT TWICE THE DIAMETER OF THE SOLAR SYSTEM.

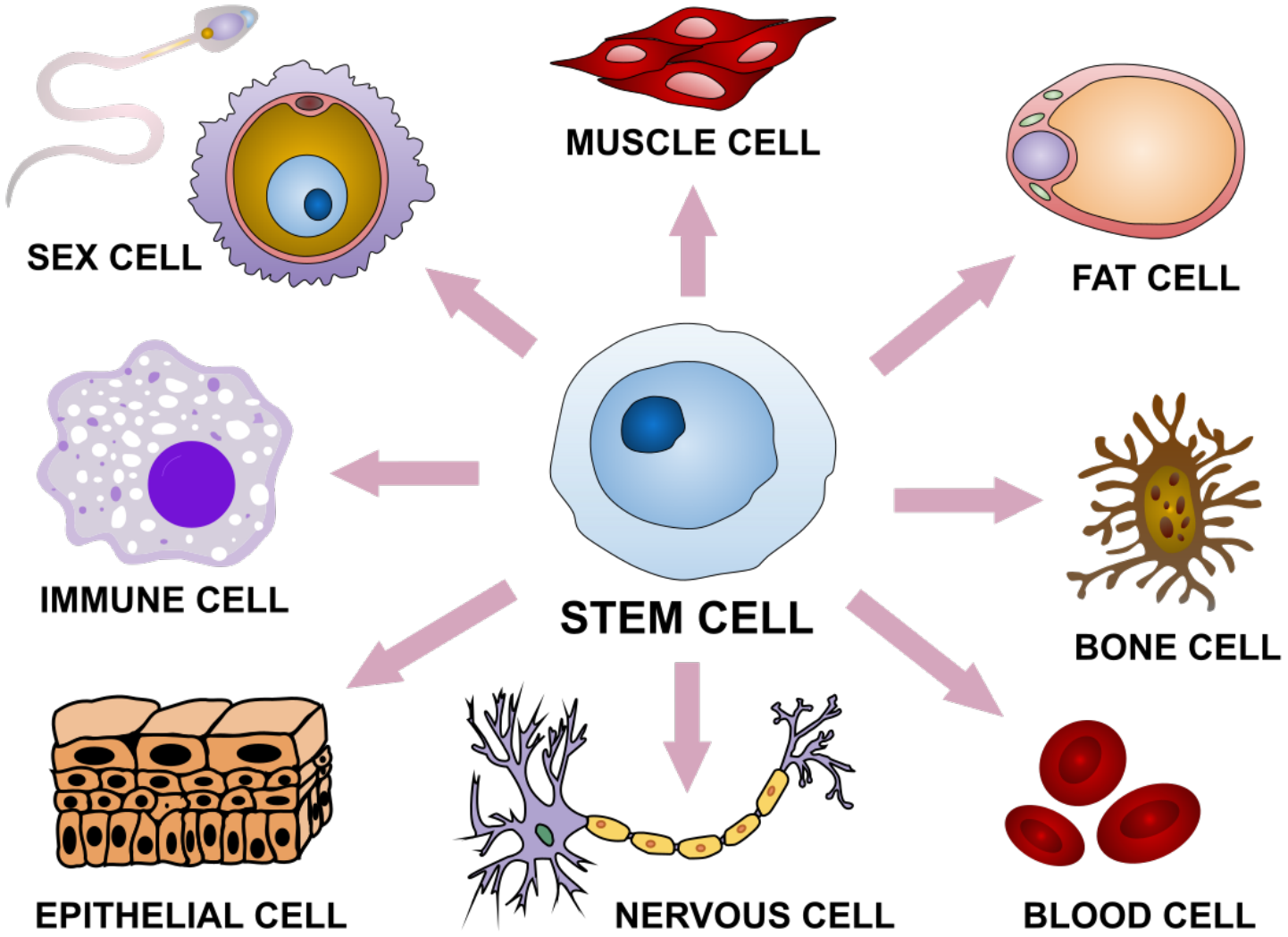


STEM CELLS

A stem cell is a “beginner” or undifferentiated cell, which retains the ability both to keep dividing for self-renewal of its population, and to become specialized in certain conditions.

Embryonic stem cells occur in the early embryo and have the ability to differentiate (change) into any of the 206 types of specialized cells in the eventual body.

Adult stem cells occur in certain tissues where they multiply rapidly as part of ongoing maintenance. In the bone marrow they produce millions of different blood cells every second.



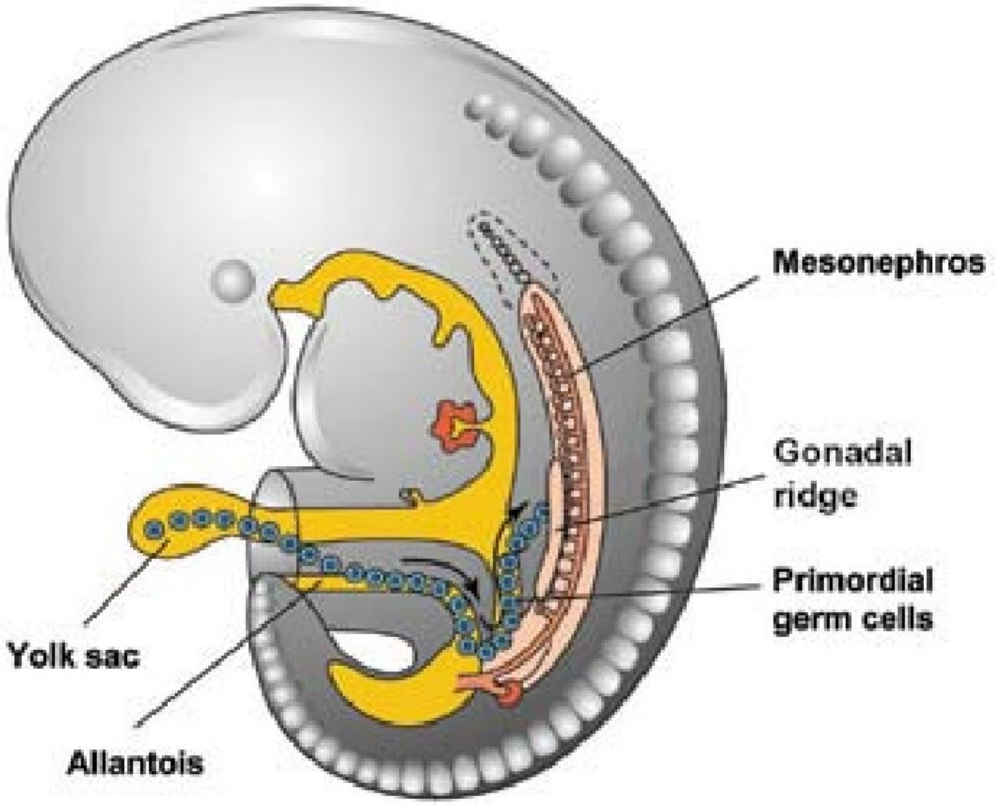
I KNOW WHERE I CAME FROM BUT WHERE DID MY DAD'S SPERM CELLS AND MY MOM'S EGGS COME FROM, AND EVERYONE WHO CAME BEFORE THEM ?

Germ cells are the stem cells of mammals and us, since they give rise to organisms rather than organs.

All gametes (egg and sperm cells) come from PRIMORDIAL GERM CELLS (PGCs), which are a small group of stem cells set aside from other cell lineages very early in embryonic life in most animal species.

Eggs - A woman is born with all the eggs that will be released in her reproductive lifetime, averaging around 590,000 inactive eggs.

Sperm - At the onset of puberty, immature reproductive cells called spermatogonia go through the process of spermatogenesis, where they begin to multiply quickly and continue to divide and divide to eventually develop mature sperm.

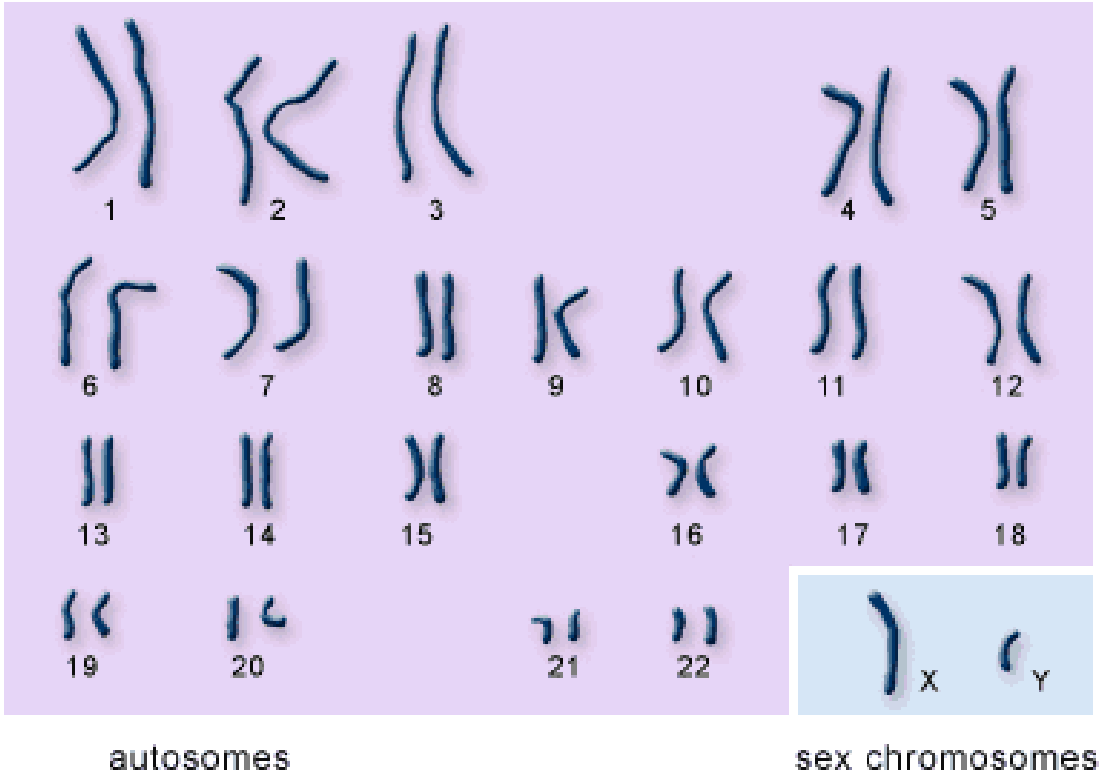


Stem cells in the yolk sac are changed into primordial germ cells and move from there into the place in the embryo where the sexual organs will be – the Gonadal ridge !!

THE HUMAN GENOME

A genome is the full set of genetic instructions for a living thing, controlling its development from a single cell into a complex, adult body.

The human genome consists of an estimated 30,000–35,000 genes, carried on the double set of 46 chromosomes found in nearly every kind of body cell.



U.S. National Library of Medicine

THE PROCESS FOR HOW THE NEW FERTILIZED CELL DIVIDES IS CALLED MEIOSIS

It is the process when cells needed for sexual reproduction divide to produce new cells – eggs in females and sperm in males, called **gametes**.

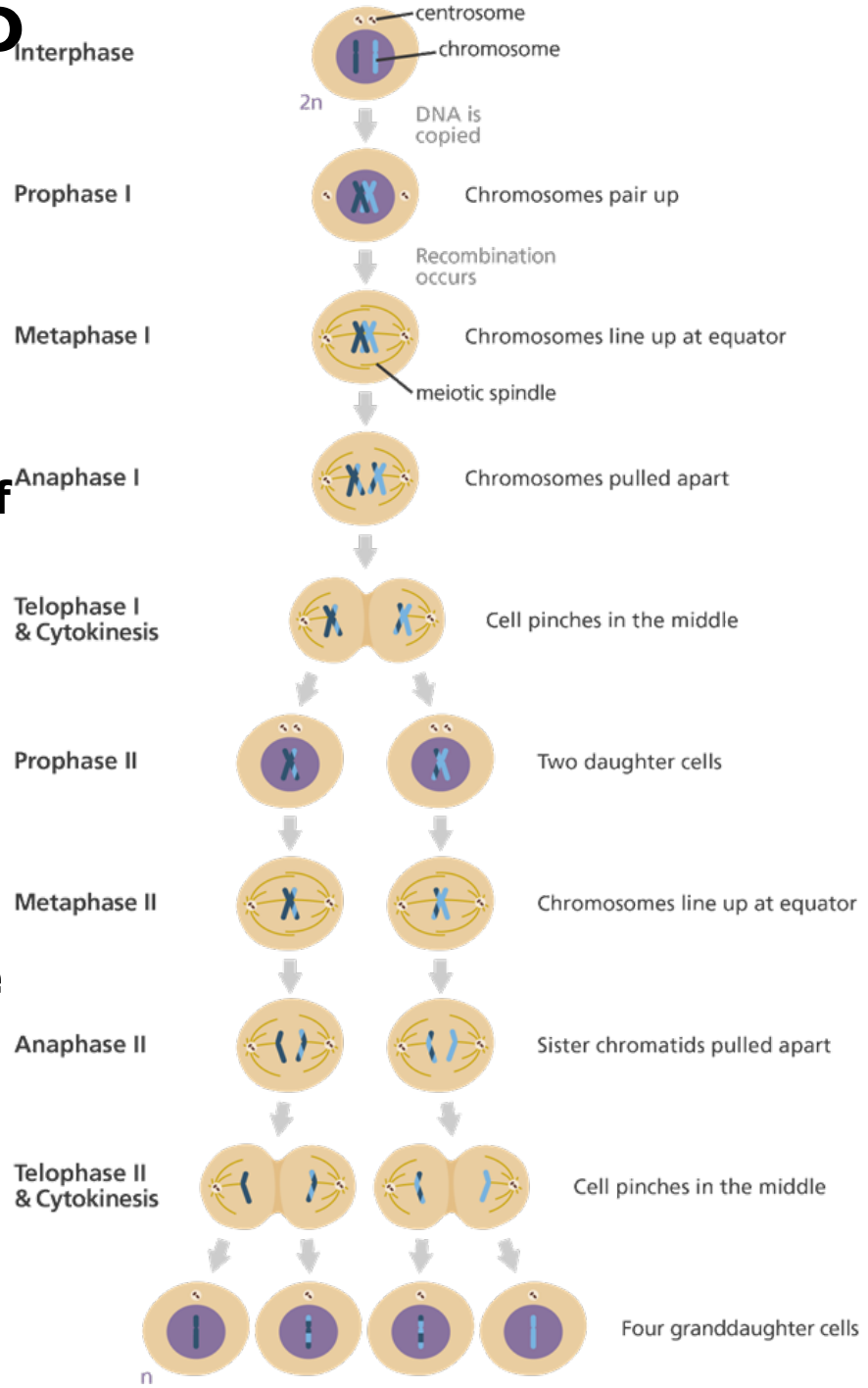
Meiosis is a process where a single cell divides twice to produce four cells, with each one containing half of the original amount of genetic information, which are called Haploid cells. **<u>It takes about 74 hours for it all to happen !!</u>**

Meiosis can be divided into nine stages. These are divided between the first time the cell divides (meiosis I) and the second time it divides (meiosis II)

An important and amazing part of this process is the "crossing over" of DNA between Father and Mother cells, creating a unique individual, as shown in the video.

Around 99.9% of your DNA is the same as that of every other human, **the 0.1% that's different is what makes you genetically unique!**

https://www.youtube.com/watch?v=GqwMDIDAkl8



CHROMOSOMES

The full set of chromosomes in a human cell is 46.

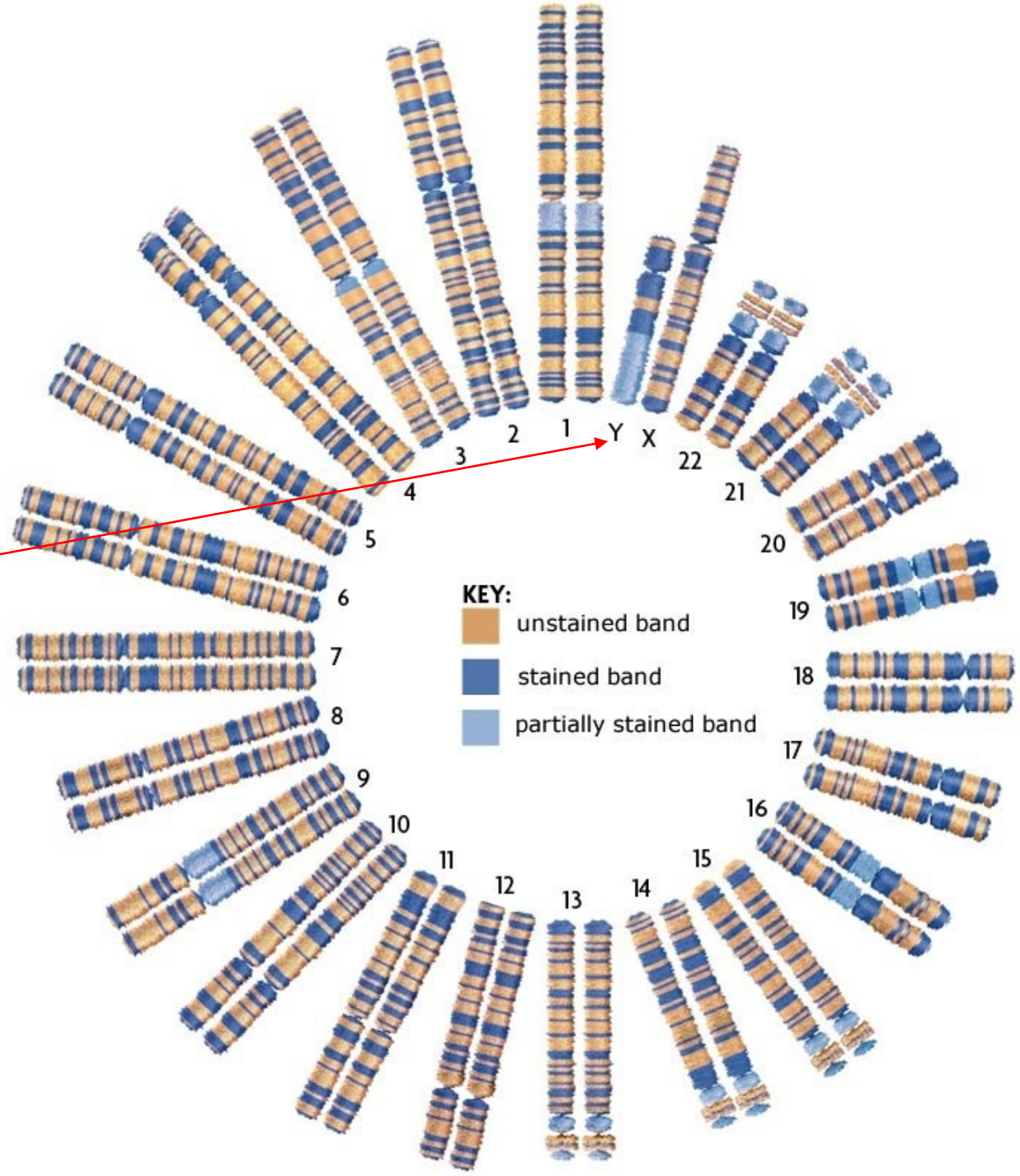
These consist of 22 equivalent pairs, one of each pair derived from the mother and one from the father.

They are numbered from 1 (largest) to 22 (smallest).

The 23rd pair is the sex chromosomes, XX signifying female and XY (as here) male.

When colored by chemical stains, dark and pale stripes called banding patterns show up on each chromosome.

These allow researchers to "map" the locations of particular genes within the chromosome.



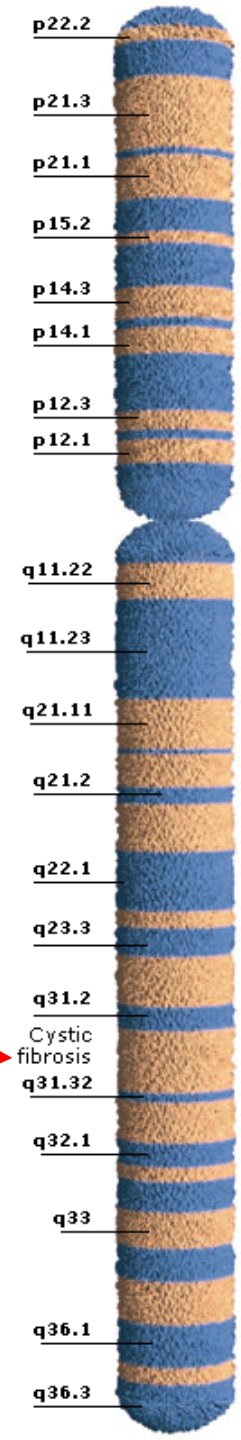
Chromosome seven

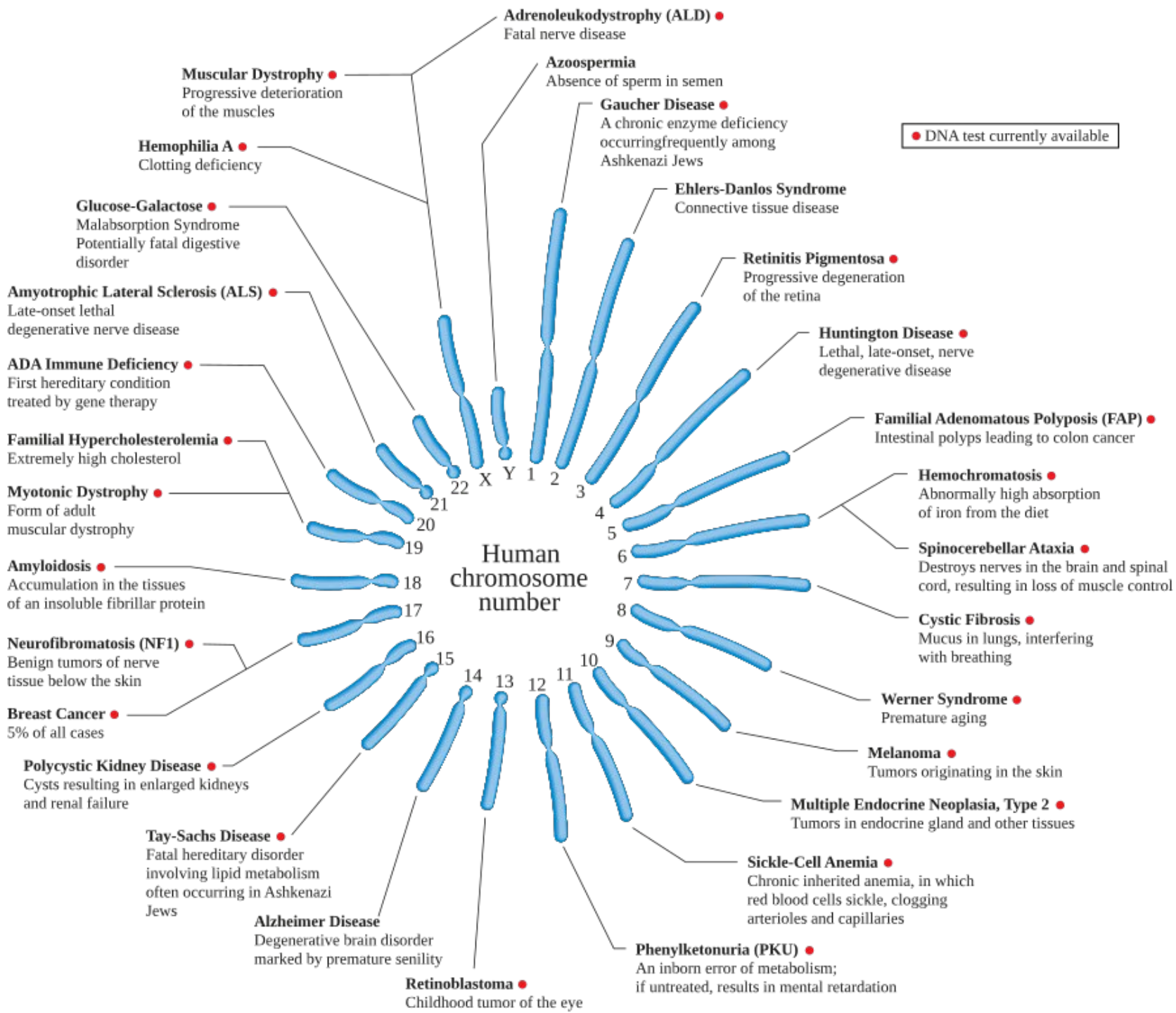
One of the first chromosomes to be sequenced, it contains more than 5 per cent of the genome's total DNA, with about 159 million pairs of bases.

Almost 60 million are in the short arm, 7p, with the rest in the longer arm, 7q.

The conventions of labelling a chromosome make it possible to find the site of the gene if you know its "address".

The cystic fibrosis gene (CFTR), for example, is located at 7q31.2




Adrenoleukodystrophy (ALD)
Fatal nerve disease
Azoospermia
Absence of sperm in semen
Muscular Dystrophy
Progressive deterioration of the muscles
Gaucher Disease
A chronic enzyme deficiency occurringfrequently among Ashkenazi Jews
DNA test currently available
Hemophilia A
Clotting deficiency
Ehlers-Danlos Syndrome
Connective tissue disease
Glucose-Galactose
Malabsorption Syndrome
Potentially fatal digestive disorder
Retinitis Pigmentosa
Progressive degeneration of the retina
Amyotrophic Lateral Sclerosis (ALS)
Late-onset lethal degenerative nerve disease
Huntington Disease
Lethal, late-onset, nerve degenerative disease
ADA Immune Deficiency
First hereditary condition treated by gene therapy
Familial Adenomatous Polyposis (FAP)
Intestinal polyps leading to colon cancer
Familial Hypercholesterolemia
Extremely high cholesterol
Hemochromatosis
Abnormally high absorption of iron from the diet
Myotonic Dystrophy
Form of adult muscular dystrophy
Spinocerebellar Ataxia
Destroys nerves in the brain and spinal cord, resulting in loss of muscle control
Amyloidosis
Accumulation in the tissues of an insoluble fibrillar protein
Cystic Fibrosis
Mucus in lungs, interfering with breathing
Neurofibromatosis (NF1)
Benign tumors of nerve tissue below the skin
Werner Syndrome
Premature aging
Breast Cancer
5% of all cases
Melanoma
Tumors originating in the skin
Polycystic Kidney Disease
Cysts resulting in enlarged kidneys and renal failure
Multiple Endocrine Neoplasia, Type 2
Tumors in endocrine gland and other tissues
Tay-Sachs Disease
Fatal hereditary disorder involving lipid metabolism often occurring in Ashkenazi Jews
Sickle-Cell Anemia
Chronic inherited anemia, in which red blood cells sickle, clogging arterioles and capillaries
Alzheimer Disease
Degenerative brain disorder marked by premature senility
Phenylketonuria (PKU)
An inborn error of metabolism; if untreated, results in mental retardation
Retinoblastoma
Childhood tumor of the eye
Human chromosome number
22
X
Y
1
2
3
4
5
6
7
8
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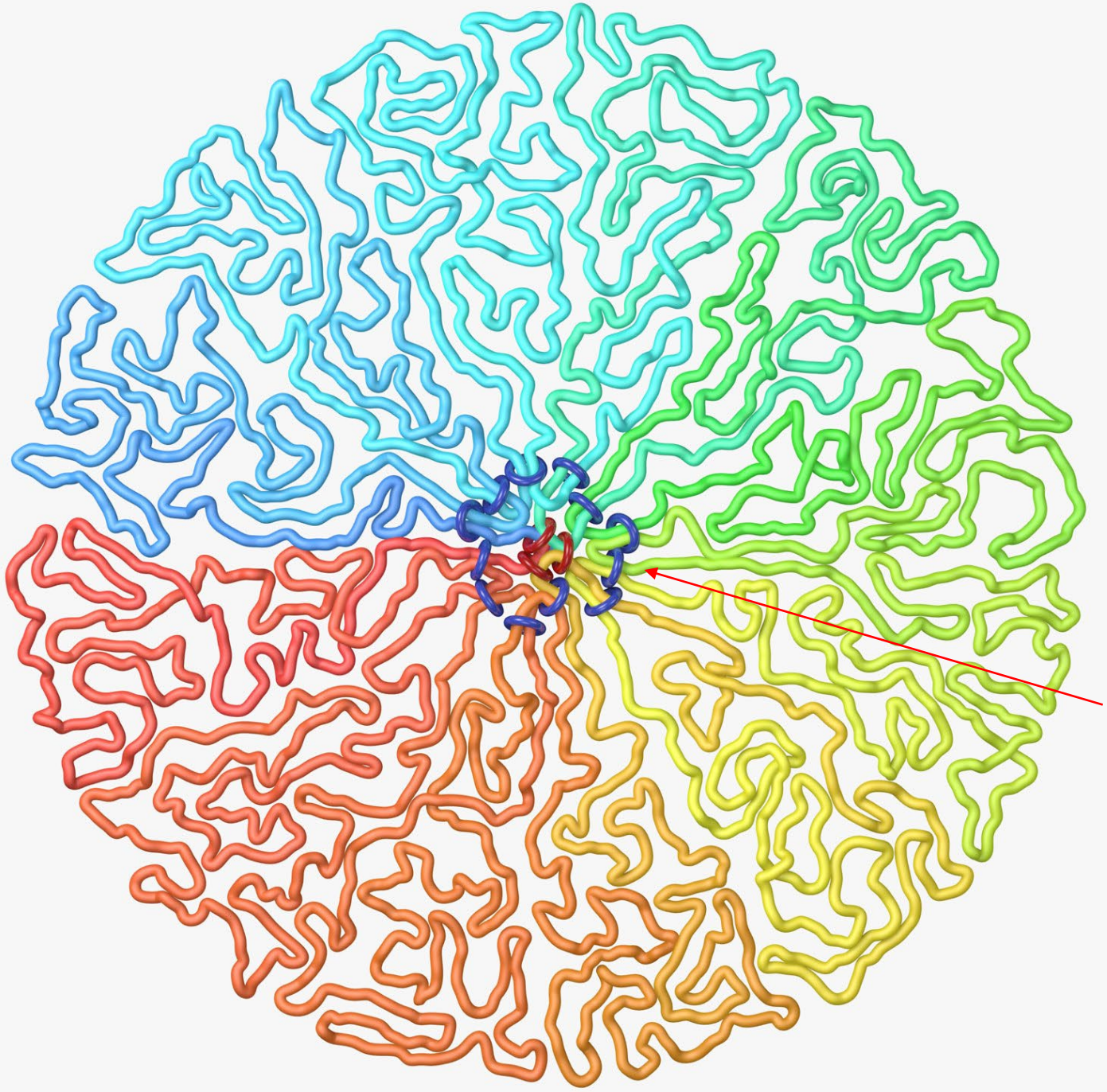
HOW THE LONG STRANDS OF DNA COILS ARE COILED EVEN MORE TO BECOME A CHROMOSOME HAS BEEN A MYSTERY FOR SOME TIME.

In February, 2018, for the first time, researchers saw how proteins grab loops of DNA and bundles them to reduce them to fit into the shape of a chromosome.



This is an illustrated cross-section of a dividing cell's chromosome shows blue and a red ring-shaped protein molecules, folding the DNA into nested loops that radiate out from a central axis.

DNA, unless being directly transcribed, will be bound to proteins called histones.

These DNA/histone structures are called nucleosomes and are approximately 11 nanometers (11 billionths of a meter) wide.

When the DNA then coils up, it does so in these nucleosomes to form chromatin, a ‘strand’ of 30 nanometer (30 billionths of a meter) in width.

Chromatin will then form loops, that then condense into 700 nanometer (700 billionths of a meter) fibers. These 700 nanometer fibers then become each of the four ‘arms’ of a fully formed chromosome.

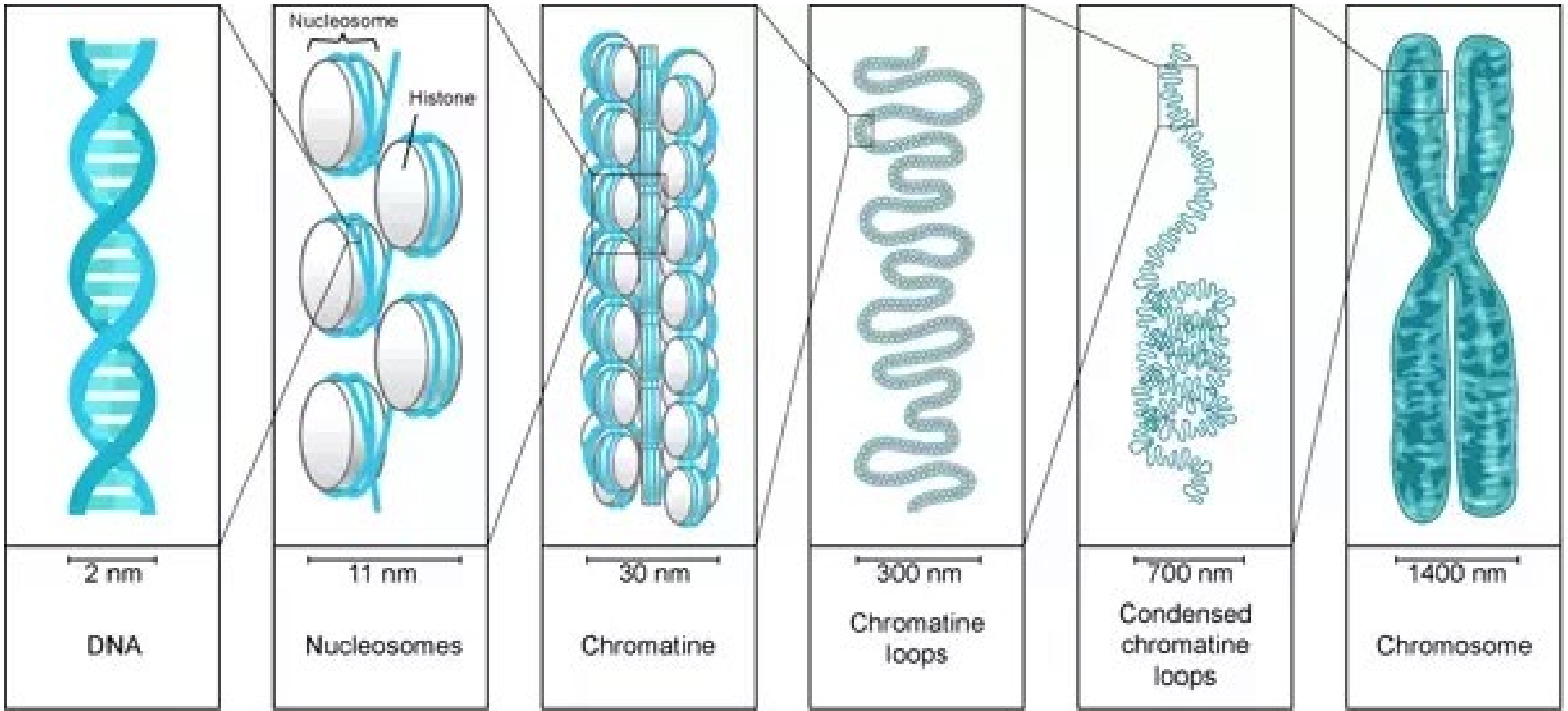


Image from google

How Cells Pack Tangled DNA Into Neat Chromosomes

https://www.youtube.com/watch?v=2ZSda7wRchc

https://www.youtube.com/watch?v=_BfRKtT5KVk

DREW BERRY

Drew Berry is a biomedical animator whose scientifically accurate and aesthetically rich visualizations reveal the microscopic world inside our bodies to a wide range of audiences.

His animations have exhibited at venues such as the Guggenheim Museum, Museum of Modern Art (New York), the Royal Institute of Great Britain and the University of Geneva. In 2010 he received a MacArthur Fellowship "Genius Award".

This is a link to a great 8+ minute TED talk that he gave about his work –

https://www.ted.com/talks/drew_berry_animations_of_unseeable_biology

My body creaks so much, my doctor just wrote me a prescription for Wd-40!

😳

Sassypants