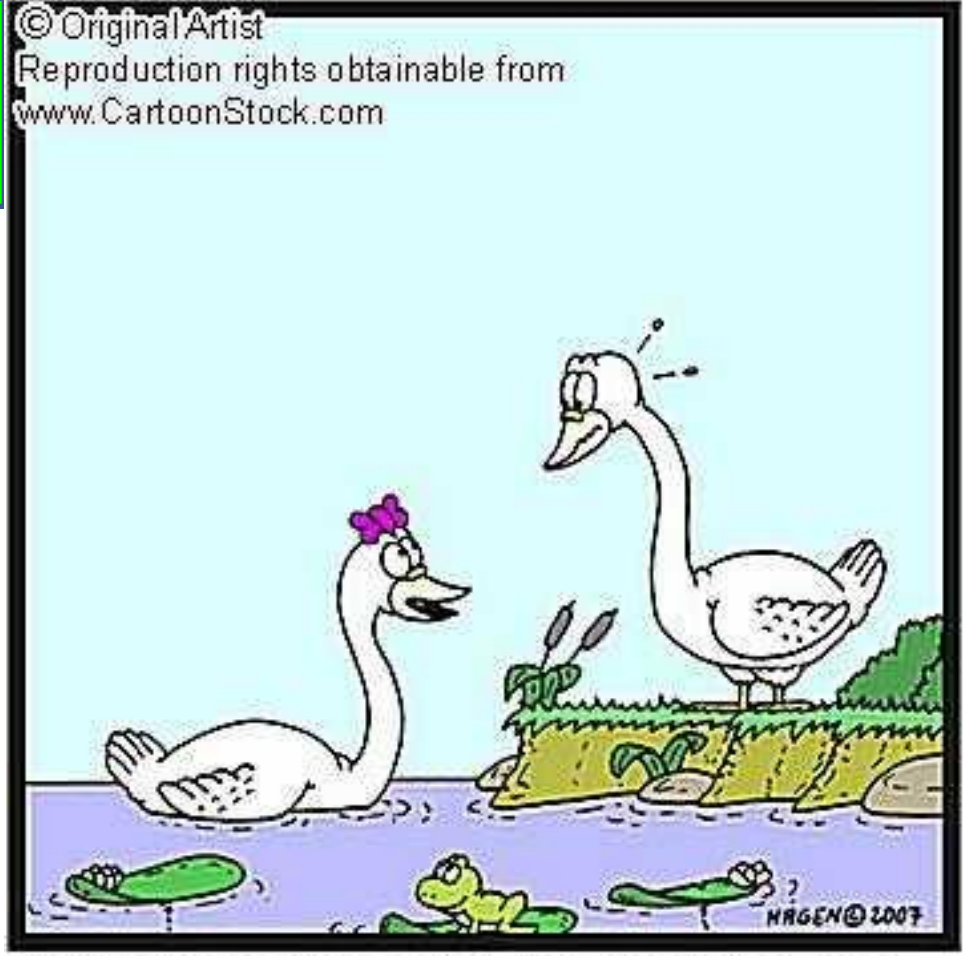
Behavioral Genetics & Epigenetics

NATURE VERSUS NURTURE



Well, you walk like a duck, you quack like a duck...
May I ask who brought you up?

What is the debate and why should we care?

Traits believed to be influenced by genes

self-control   imagination

decision making   sociability

Dopamine-4 receptor gene tied to thrill seeking and reactions to stress

What if something was 100% genetic?

Concordance results showing greatest genetic contributions

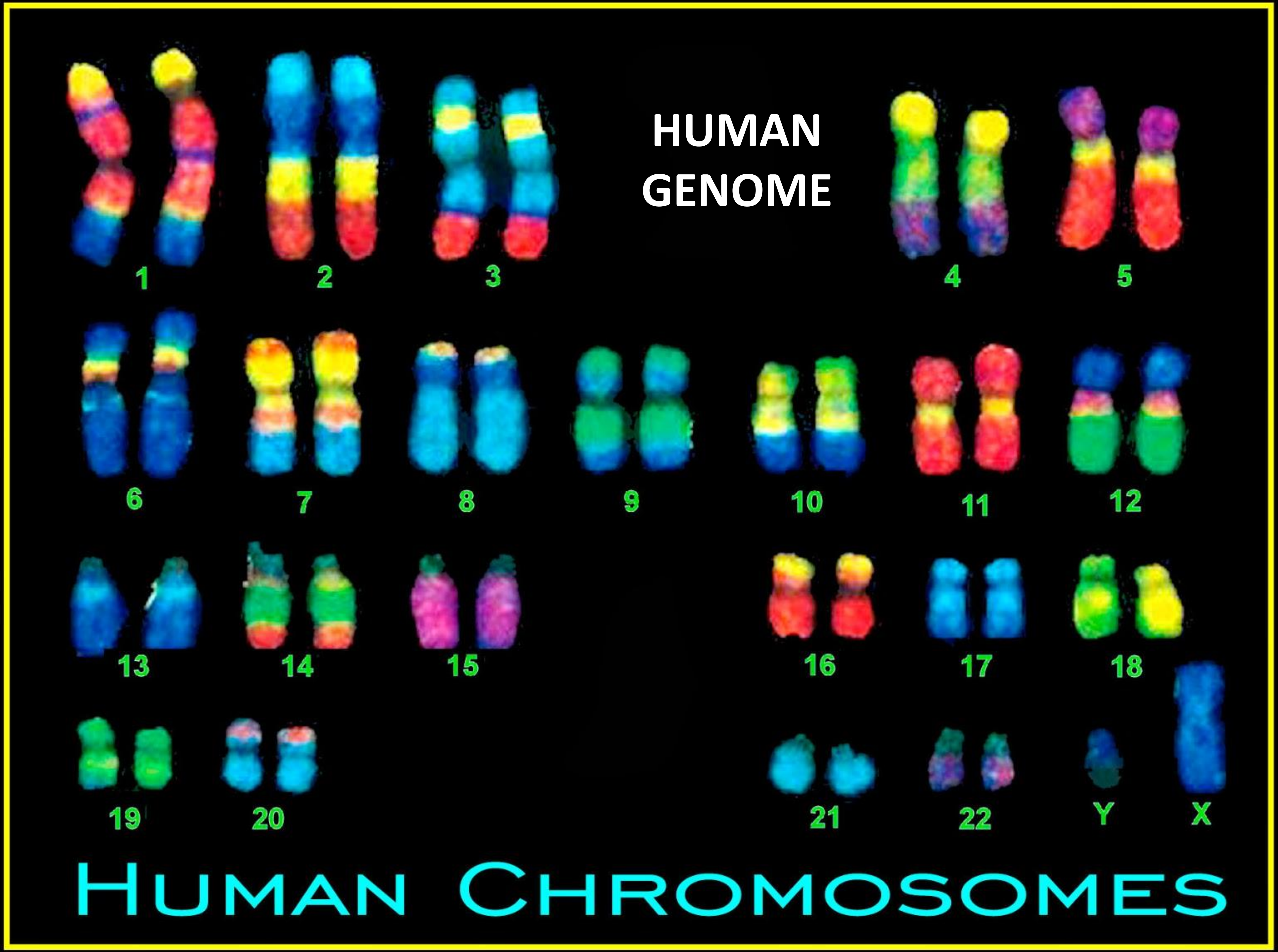
Identical twins reared together	100% same genetic code
Identical twins reared apart	100% same genetic code
Fraternal twins reared apart	share 50% DNA
Fraternal twins reared together	share 50% DNA
Normal siblings reared together	share 50% DNA
Normal siblings reared apart	share 50% DNA
Strangers	share .1% DNA

Concordance rate the percentage of pairs of twins (MZ & DZ), blood relatives, and strangers who both exhibit a particular trait or disorder

What is something was 100% environment

Concordance results showing greatest environmental contributions

Identical twins reared together	same womb, same home, same time
Fraternal twins reared together	same womb, same home, same time
Identical twins reared apart	same womb, same time
Fraternal twins reared apart	same womb, same time
Normal siblings reared together	same home
Normal siblings reared apart	shared environment as strangers
Strangers	



Except the gametes, there are 23 pairs of chromosomes = 46 chromosomes total in every cell

A chromosome is made up of neatly packaged DNA

The DNA found in each chromosome is made up of two strands.

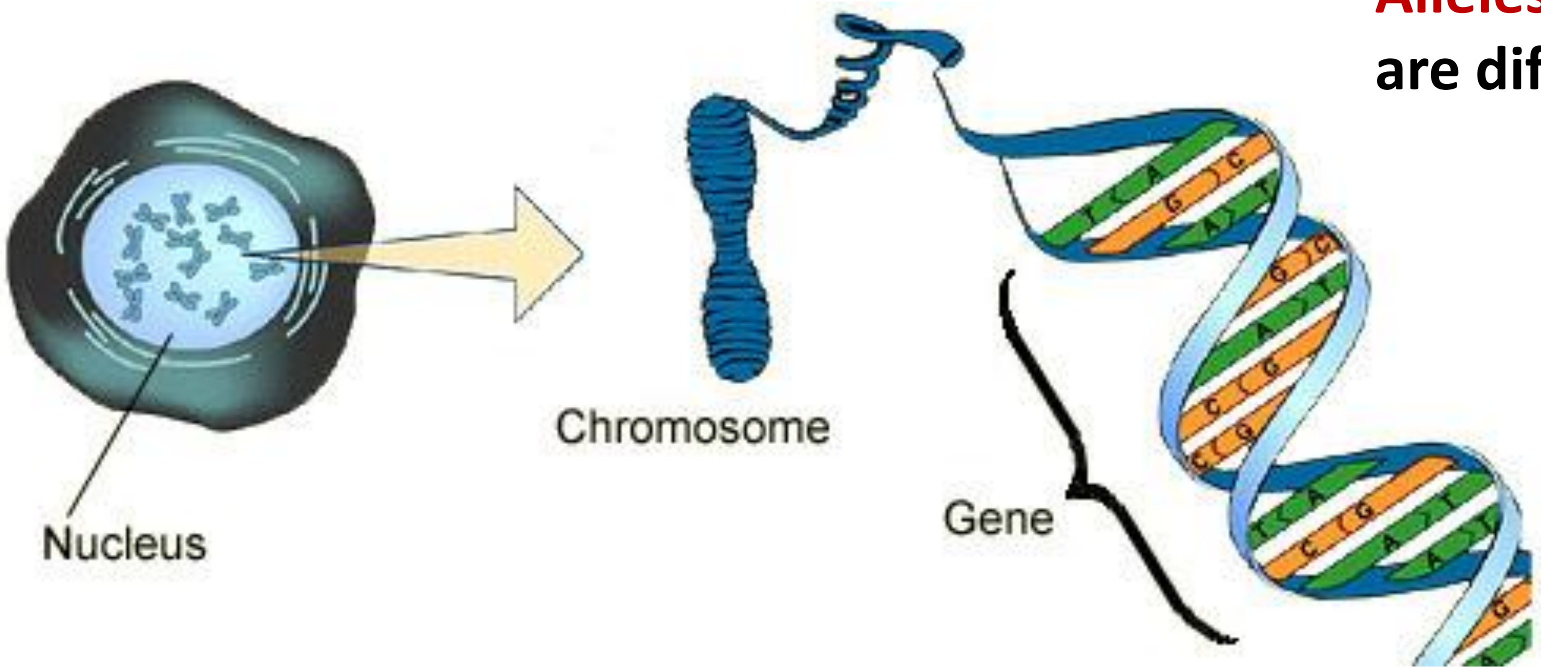
Each cell has 92 strands of DNA

GENETICS: JUST THE FACTS JACK

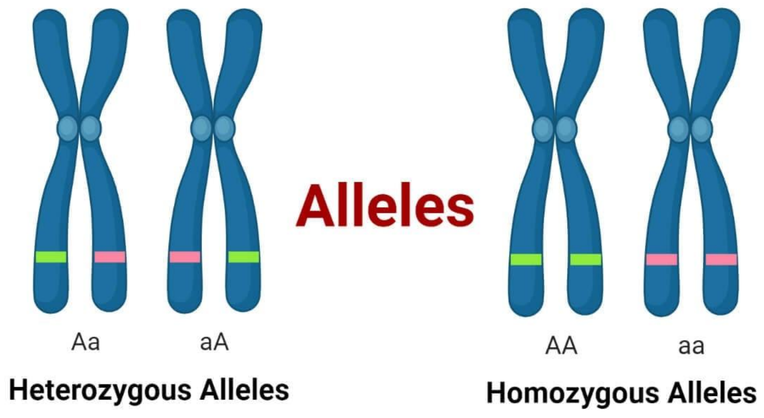
CHROMOSOMES 23 pairs in every cell except the gametes
each numbered chromosome contains a different set of genes

DNA The order of the 4 bases constitutes our **GENETIC CODE**

GENE a particular section of DNA that provides codes for specific proteins
these codes are read by ribosomes in the cytoplasm
ribosomes assemble amino acids into proteins – according to the code



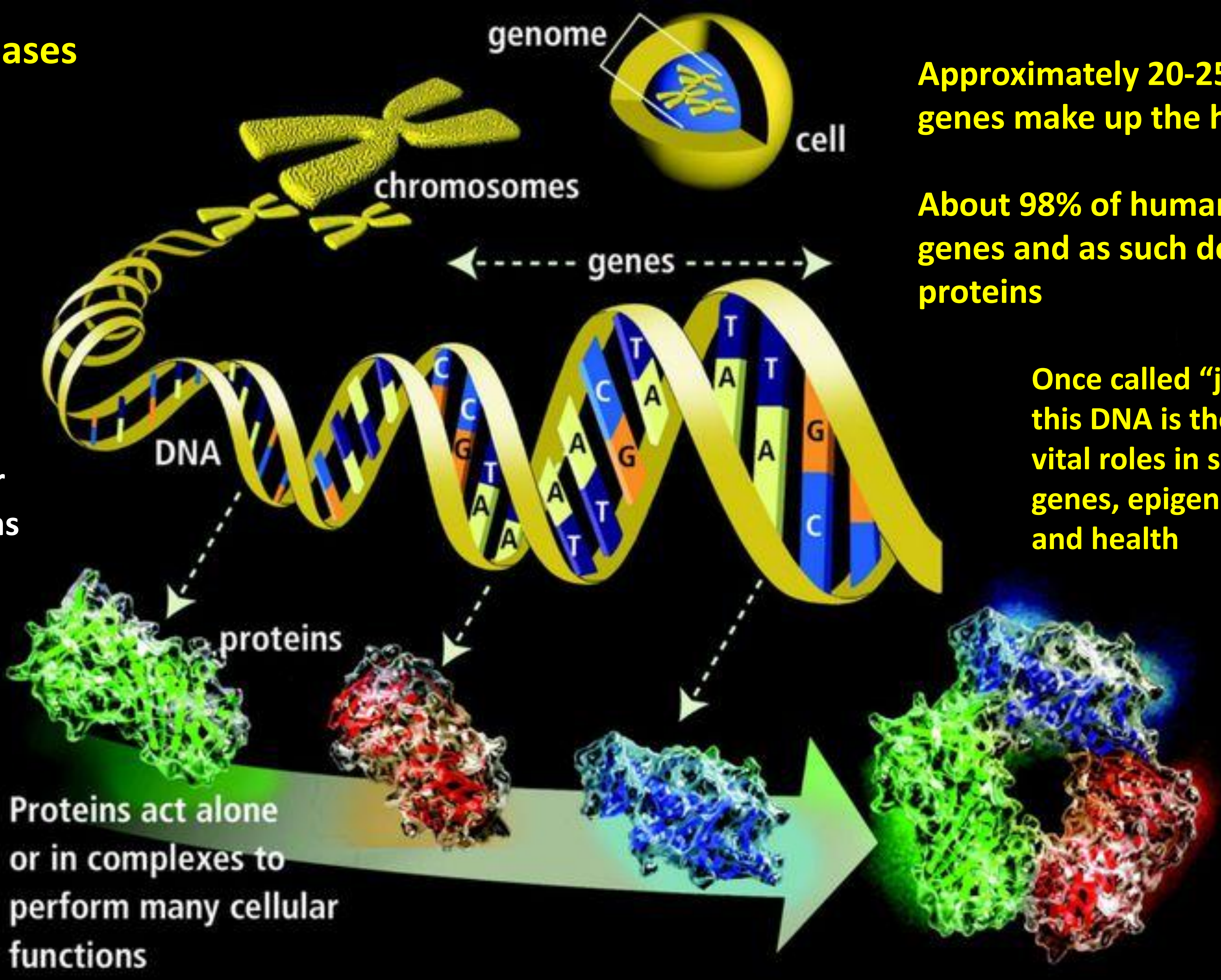
Alleles
are different versions of a gene



Nucleotide Bases

Thymine
Adenine
Guanine
Cytosine

Genes contain instructions for making proteins



Approximately 20-25K genes make up the human genome

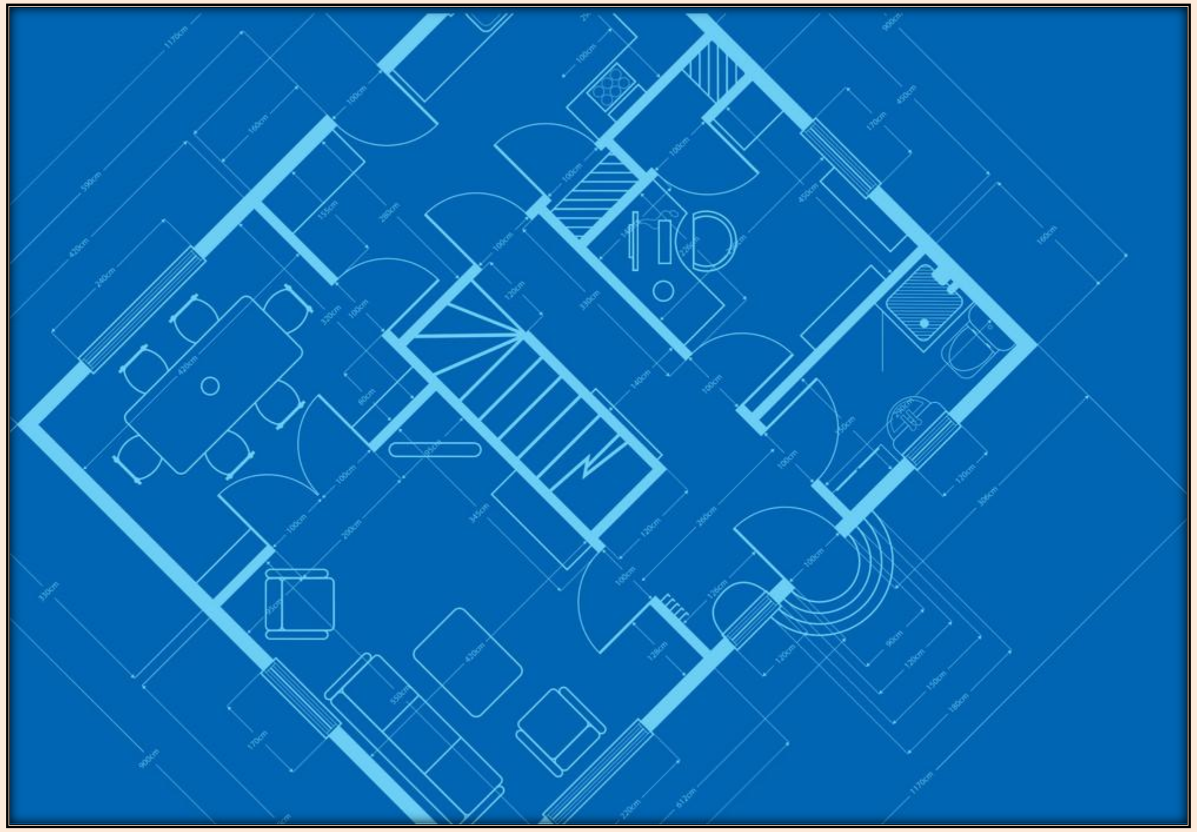
About 98% of human DNA are not genes and as such do not code proteins

Once called “junk DNA” this DNA is thought to play vital roles in supporting genes, epigenetics, and health

Genotype

VS

Phenotype

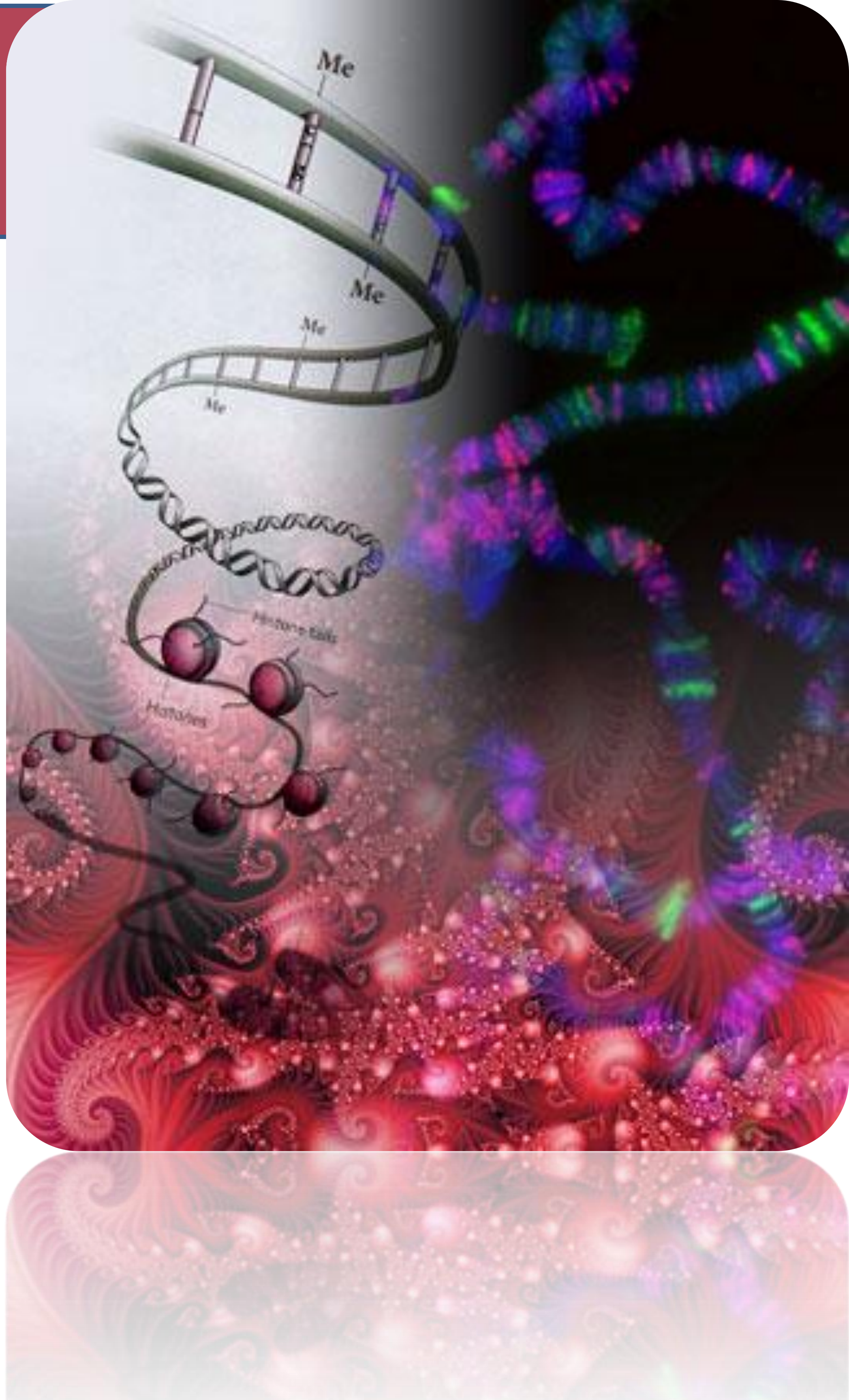


Epigenetics

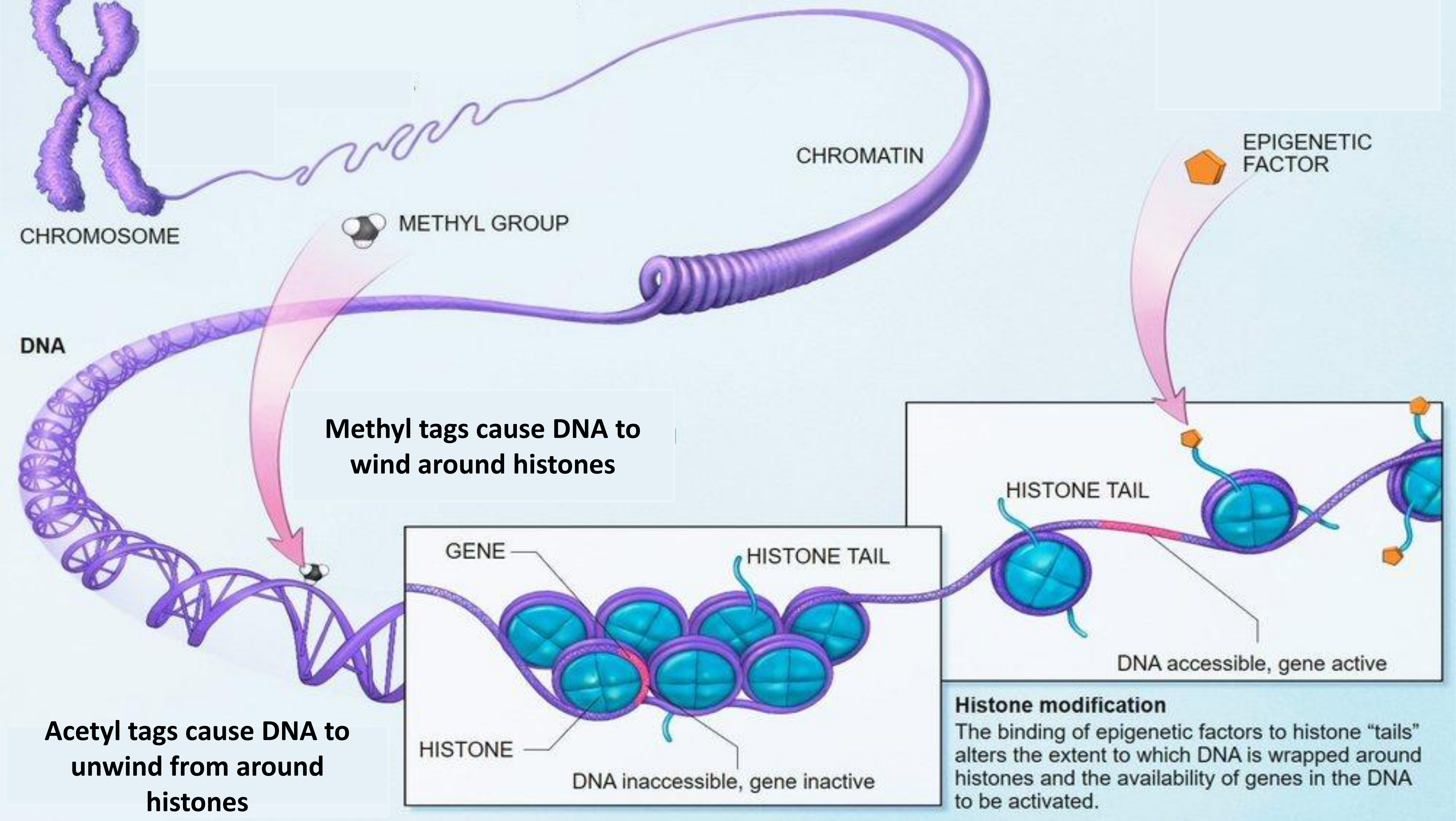
the study of the environmental and behavioral influences that "turn genes on and off" thereby
affecting how the genetic code is read.

This alters genetic expression – one's phenotype

Epigenetics is
the bridge between
body, mind,
& environment



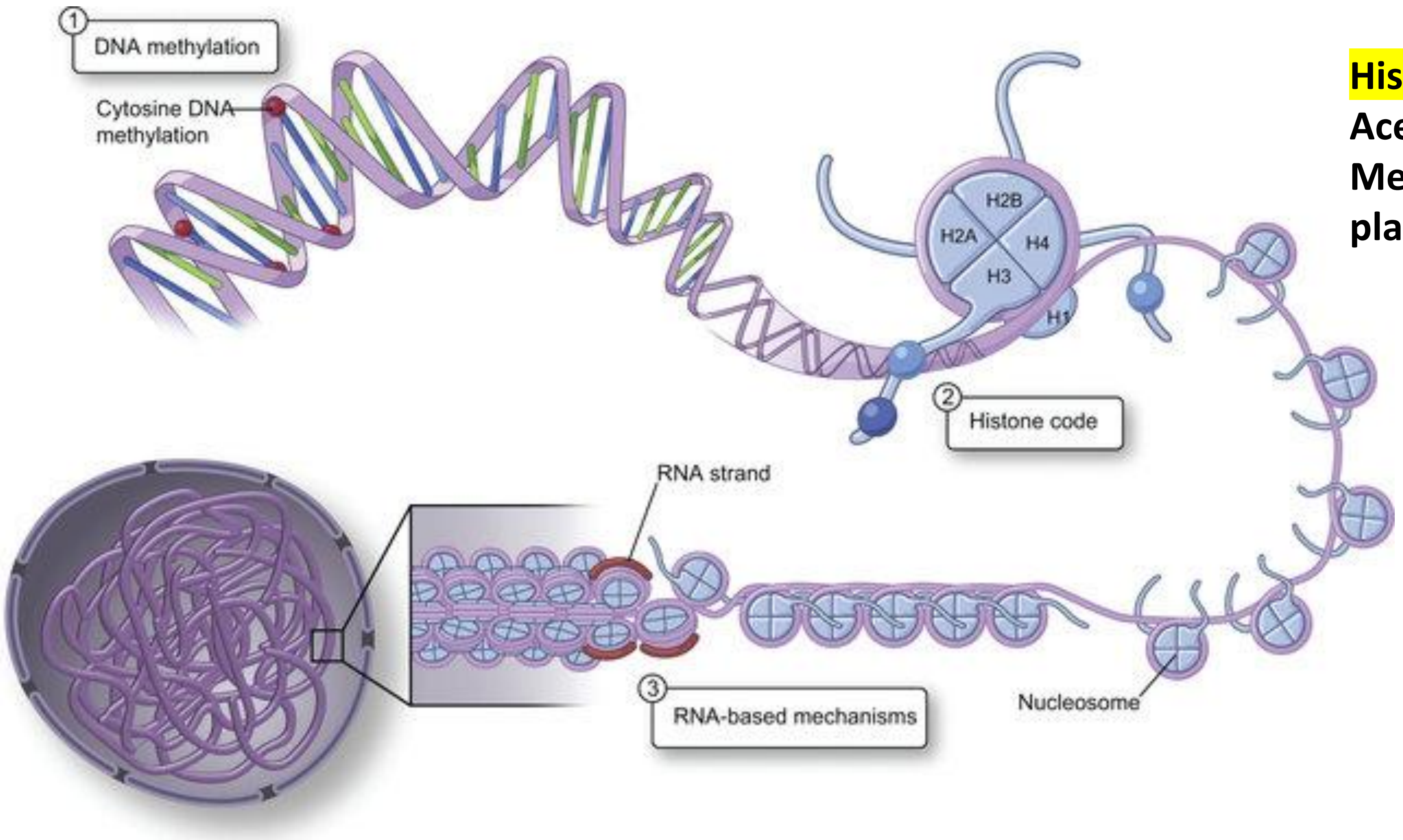
DNA is negatively charged while histone tails are positively charged, thus, providing DNA adherence to histones



Histone modification
The binding of epigenetic factors to histone "tails" alters the extent to which DNA is wrapped around histones and the availability of genes in the DNA to be activated.

Three Mechanisms of Epigenetics

DNA methylation: methyl group attaches to the DNA itself – "permanently" disabling the gene in that area



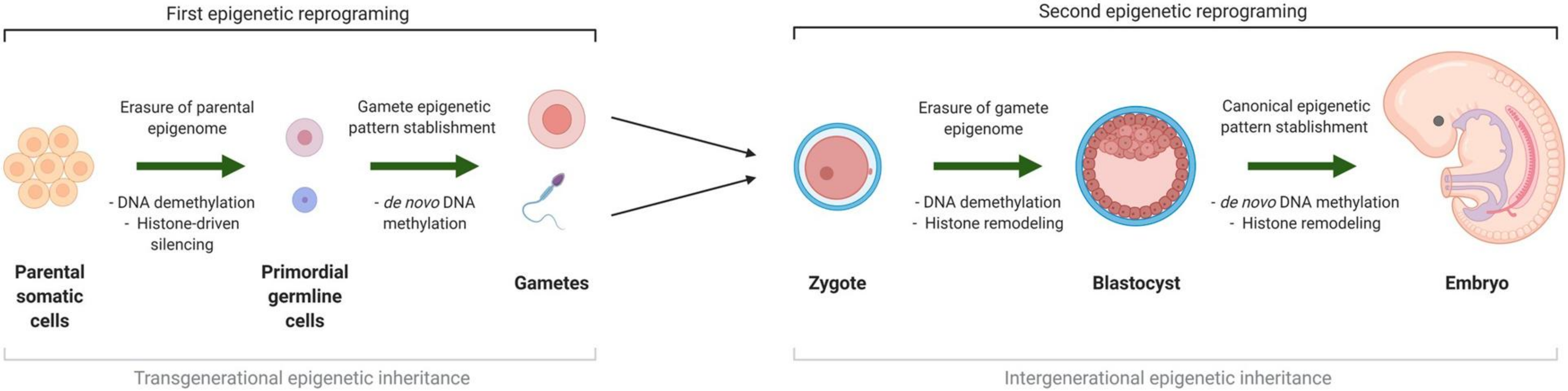
Histone modification via histone tails
Acetyl tags allow for genes to be read
Methyl tags mostly "hide" genes but in some places, they may actually have opposite effect

Non-coding RNA: attaches to protein coding RNA, breaking it down so that it cannot be used to make proteins. Non-coding RNA may also recruit proteins to modify histones to turn genes "on" or "off."

Epigenetic Inheritance Theory

Epigenetic alterations can persist through cell division – epigenetic memory – within an individual's lifespan

Most maternal and paternal epigenetic tags are erased before zygote formation - epigenetic re-programming



Some tags survive!

Gene off: their DNA cannot be transcribed into mRNA to make proteins

Factors that Affect Epigenetic Tags

Development (in utero & childhood)

Environmental Chemicals

Drugs/Pharmaceuticals

Emotions

Aging

Diet

Conditions affected by Epigenetics

Autoimmune disease

Mental disorders

Cancer

Obesity

CHD

Gene on: their DNA CAN be transcribed into mRNA to make proteins

Genetic Diseases

Single-Gene

Change to a single gene
* DNA sequence may be changed
* Deletion of one or more bases
* Duplication/insertion of one or more bases

cystic fibrosis,
Fragile X syndrome
Tay-Sachs, and
sickle cell anemia

Chromosomal

aneuploidy
abnormal chromosome number
(i.e. extra or missing chromosome)

Down syndrome: An extra copy of chromosome 21

Multifactorial

Genetic x behavior x environment
Cause

Neural tube defects
Diabetes
Cancer
CHD

Cytogenetic testing

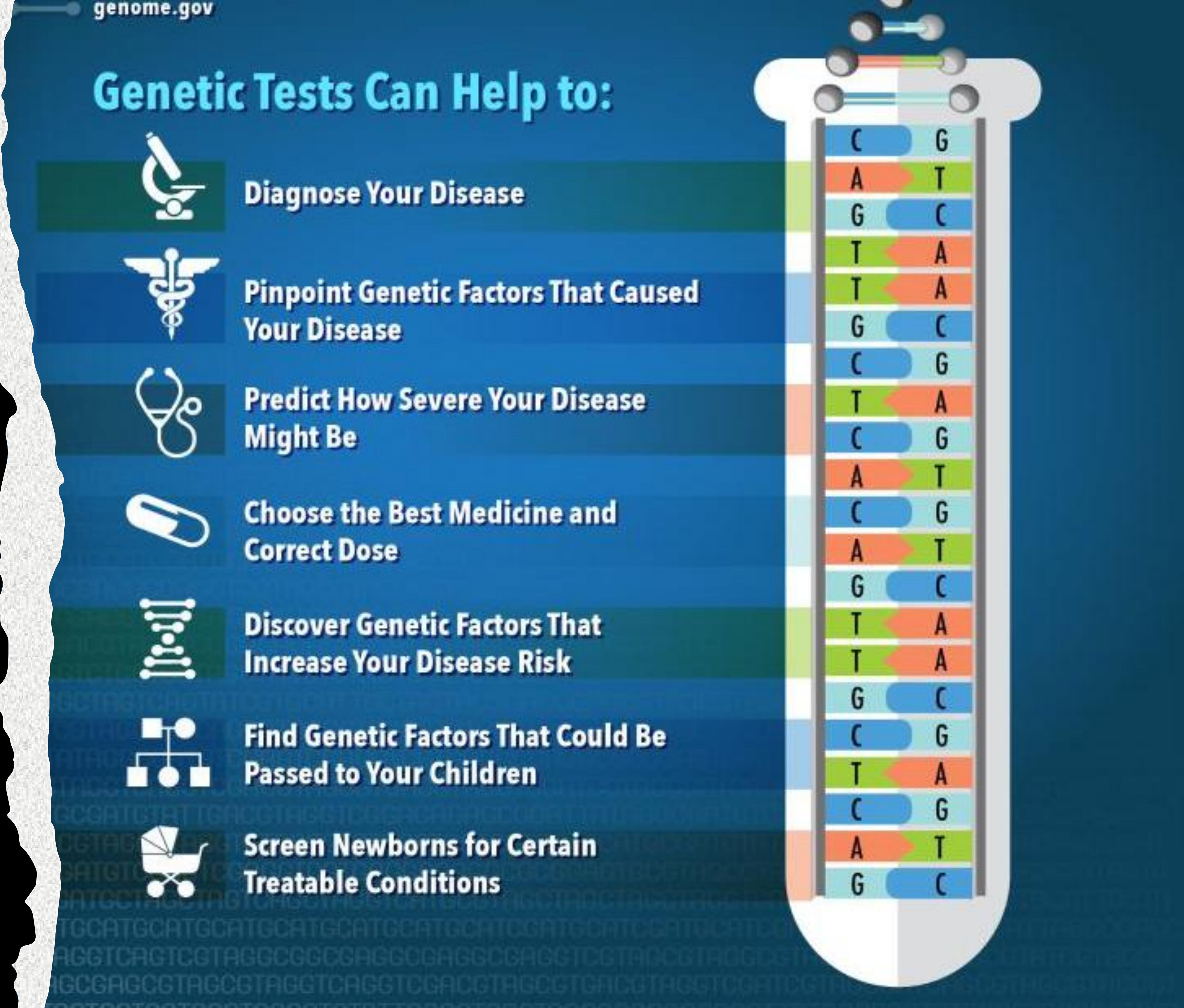
examination of chromosomes on a **karyotype** - number, size, shape, and structure - to detect genetic disorders and some types of cancer

Biochemical testing

examine the function, amount, or structure of **proteins** instead of the DNA itself to detect metabolic disorders - phenylketonuria (PKU), Tay-Sachs disease, cystic fibrosis

Molecular testing

uses a sample of tissue, blood, or other body fluid to check for **biomarkers** - certain genes, proteins, or other molecules that may be a sign of a disease or condition, such as cancer



Pharmacogenomics & Precision Medicine

Gene expression affects both pharmacodynamics & pharmacokinetics

Pharmacogenomics

new treatments tailored to an individual's genetic makeup

Precision Medicine

improve treatments by tailoring the treatment to the person's specific genetic makeup, lifestyle, environment etc

Pharmaceutical manipulation of genes vs. neurotransmitters

Relatively few genes control the formation of thousands of receptors
manipulating the gene would have a greater impact

When a drug is stopped, treatment effects decline
epigenetic manipulations can be self-sustaining

Epigenetic therapy may create a favorable environment for other drugs to work

Optoepigenetics

Optogenetics: using light to activate or deactivate neurons that are genetically modified to express a light-sensitive channel.

Optoepigenetics: adapt this technology to regulate gene expression

Optogenetics: modulation of epigenetic states on a timescale that is similar to many behavioral and neuronal phenomena

(faster than drugs)

Genetic Engineering

This is where it gets 

We have the ability to change the DNA of an organism, creating a genetically modified organism (GMO)

- Most of the plant food we eat comes from GMOs.
- transgenic organisms have DNA inserted from a different species to form a new species
- knockout mice or rats are animal models for research with targeted genes removed or disabled
- CRISPR-Cas9: relatively new way to accurately and easily change or alter DNA

Genetic Engineering and Epigenetic Possibilities

With Crispr, we can deliver enzymes that regulate specific epigenetic modifications directly to genes of interest

With Crispr, methylation and de-methylation of specific DNA sequences is possible. Need to be able to monitor changes and choose the correct DNA locations

With Crispr, we can artificially induce targeted histone modifications. We can conduct controlled experiments not possible with global pharmaceutical manipulations