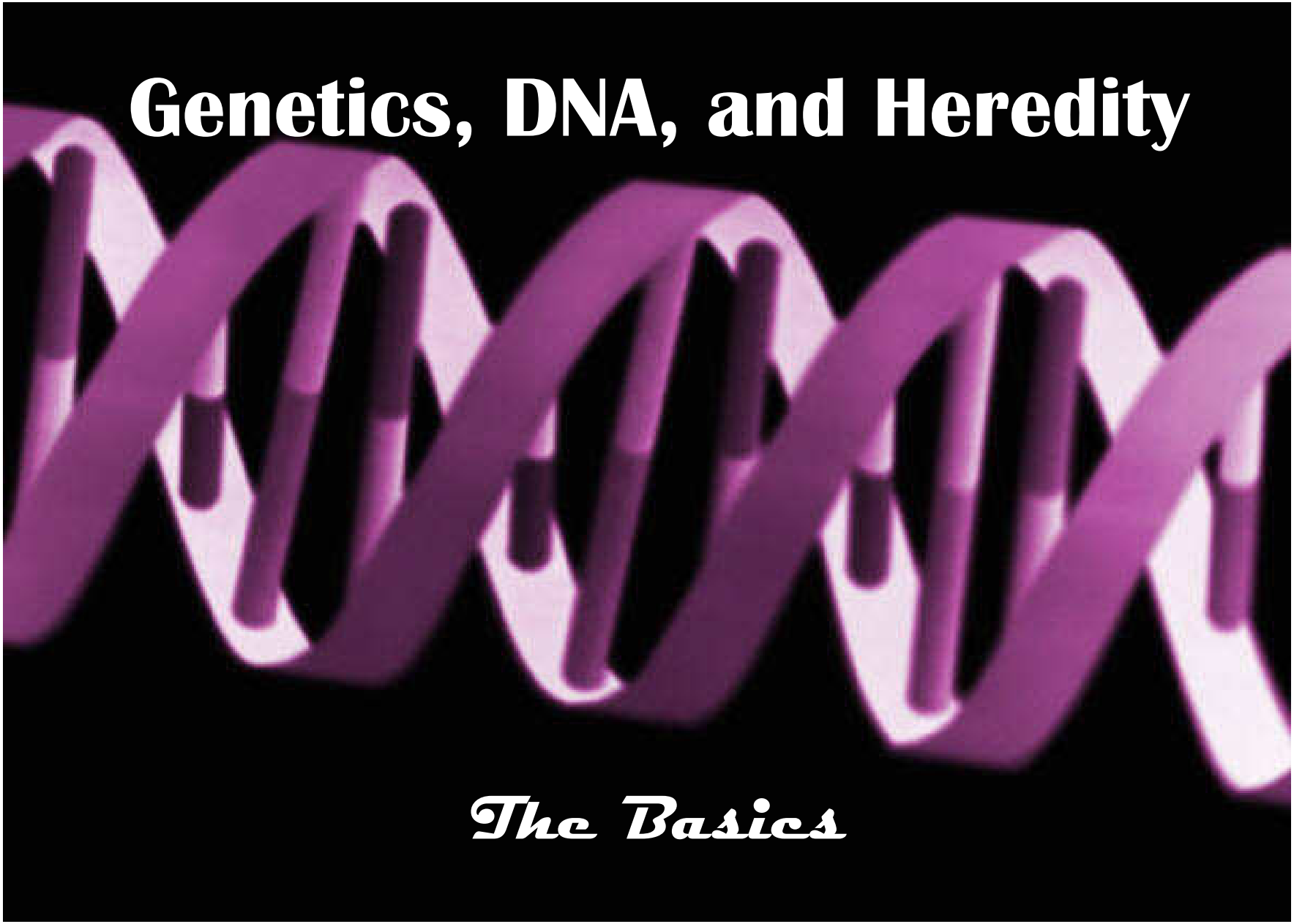
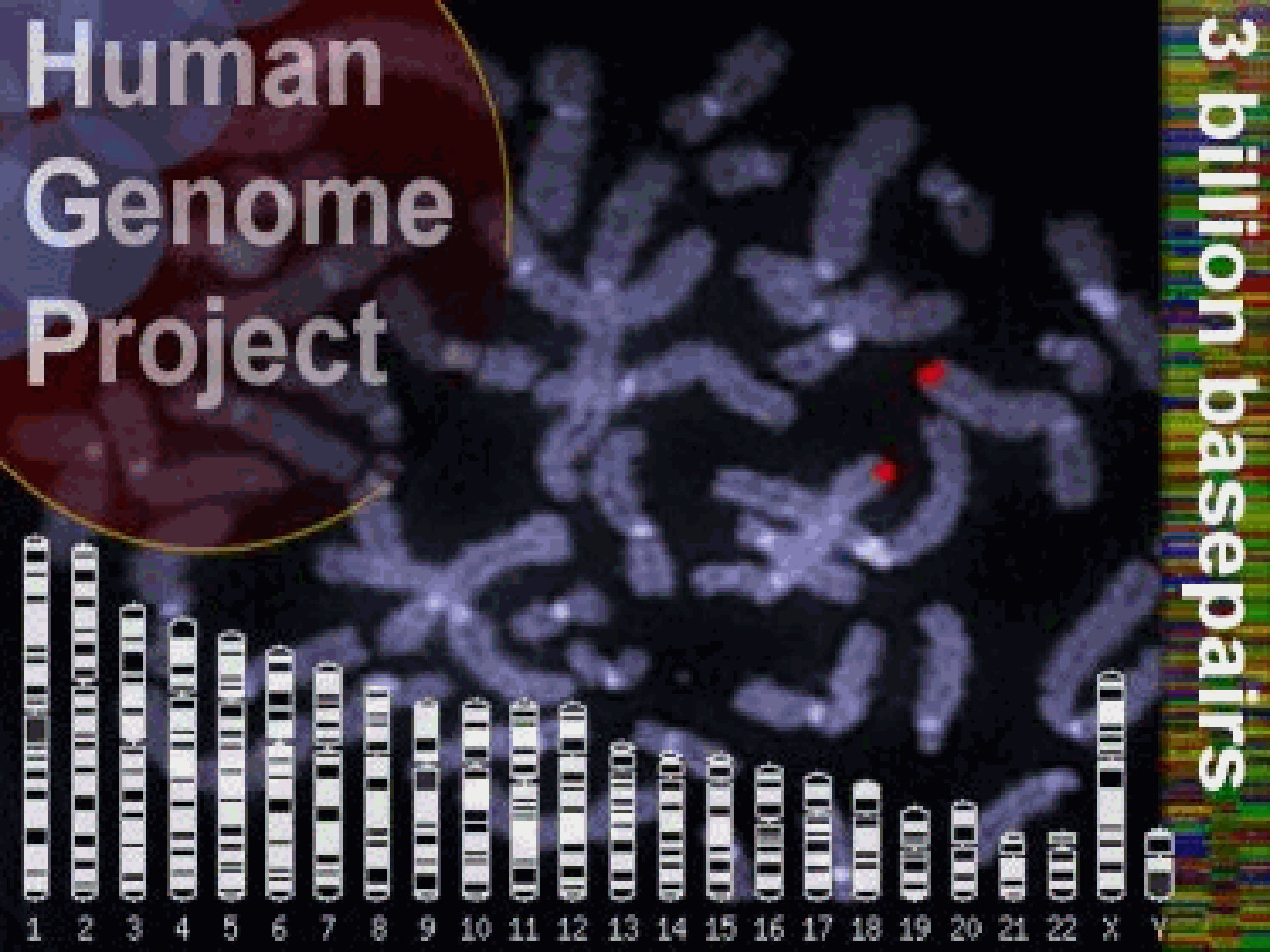
Genetics, DNA, and Heredity



The Basics

Human Genome Project



What is DNA?

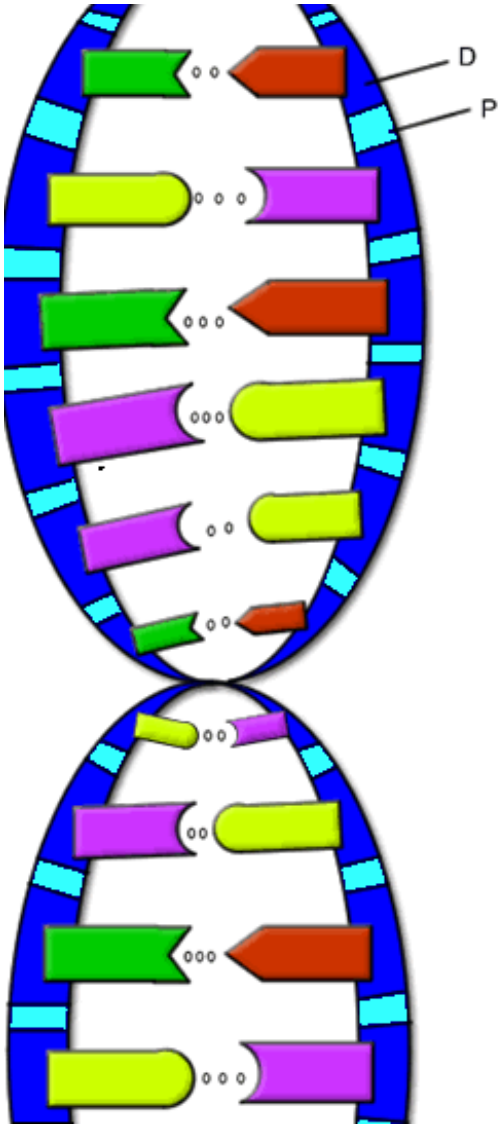
It's a history book - a narrative of the journey of our species through time.

It's a shop manual, with an incredibly detailed blueprint for building every human cell.

And it's a transformative textbook of medicine, with insights that will give health care providers immense new powers to treat, prevent and cure disease."

- Francis Collins

What Does DNA Look Like?



Thymine

Adenine

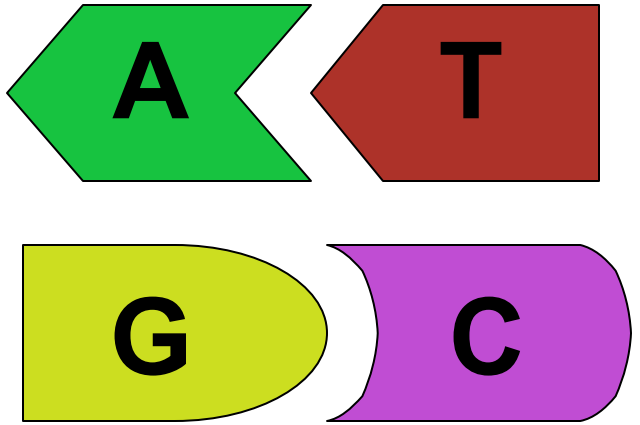
Guanine

Cytosine

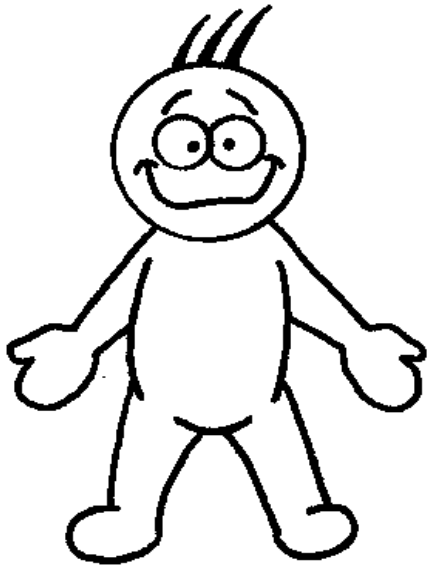
D = Deoxyribose (sugar)

P = Phosphate

Hydrogen Bond



Every cell in our body has the same DNA….

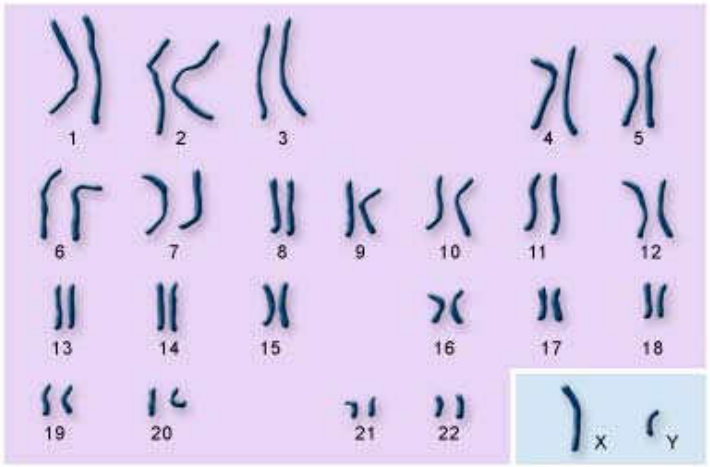


Eye cell

Lung cell

Toe cell

Karyotype



autosomes

sex chromosomes

U.S. National Library of Medicine

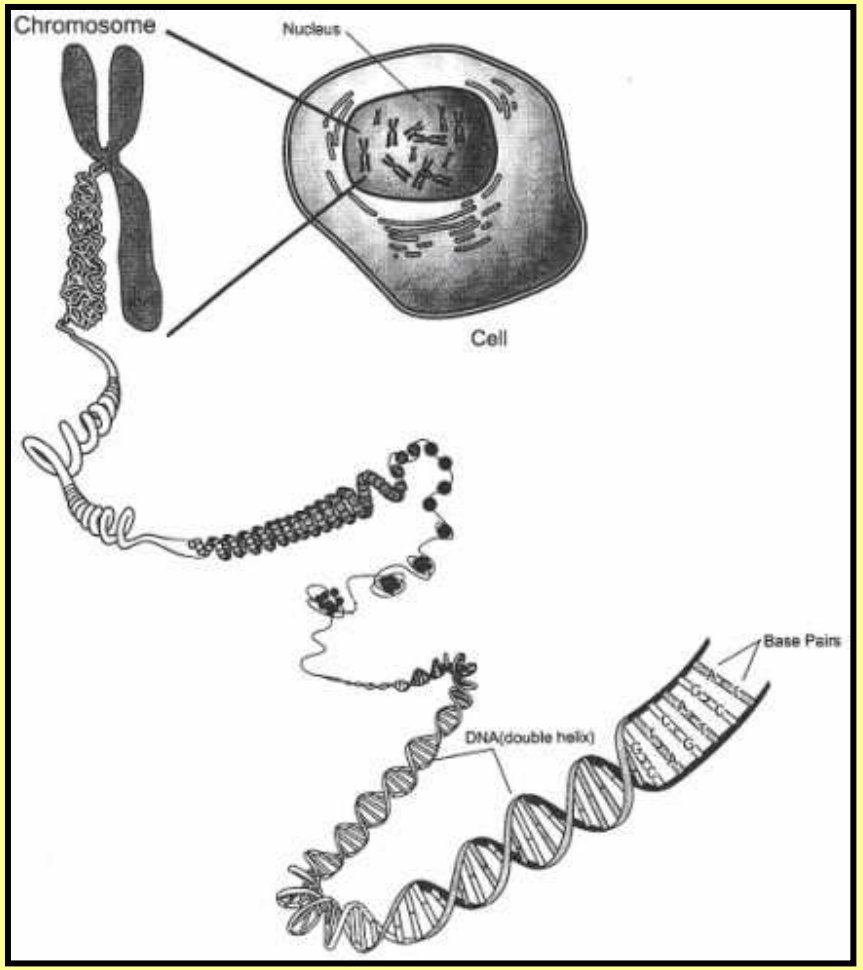
How much DNA is in one cell?

Genome = 46 chromosomes

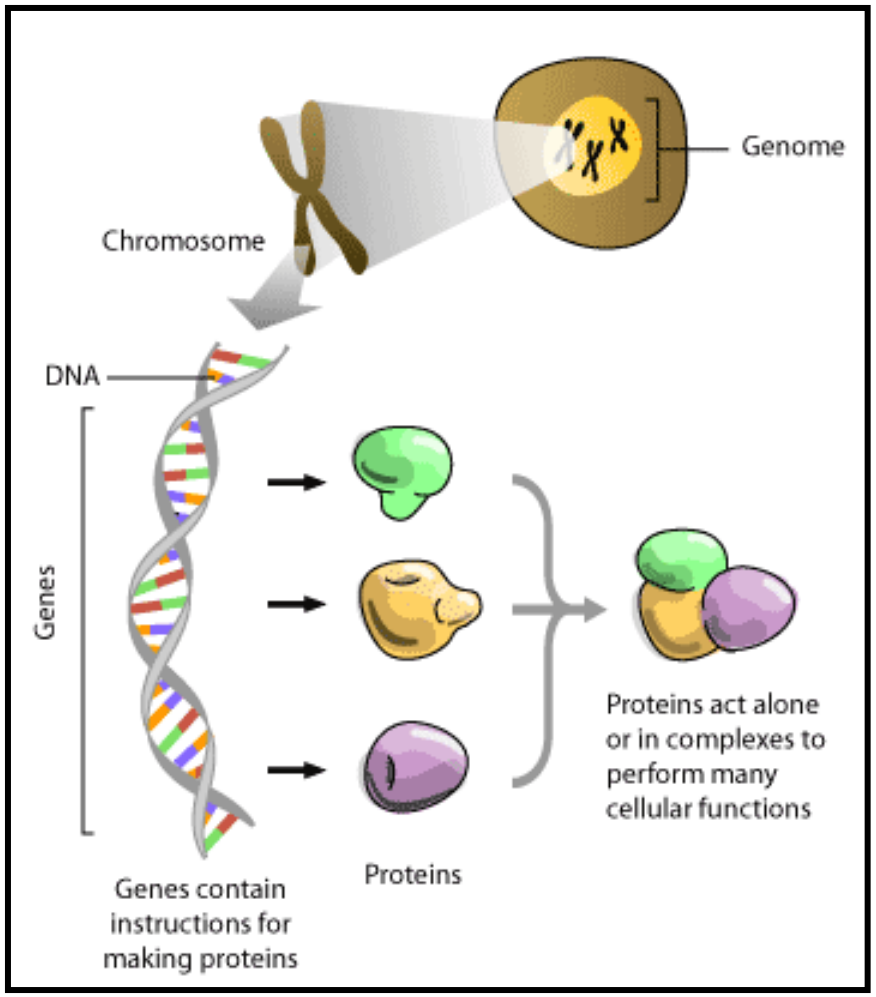
Genome = approx. 3 billion base pairs

One base pair is 0.00000000034 meters

DNA sequence in any two people is 99.9% identical – only 0.1% is unique!



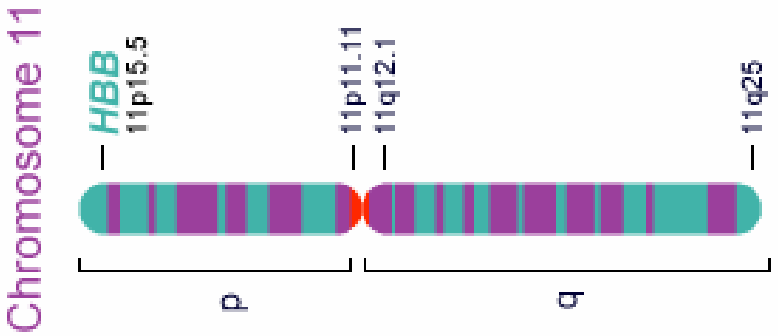
What makes one cell different from another?



DNA = "the life instructions of the cell"

Gene = segment of DNA that tells the cell how to make a certain protein.

Allele = one of two or more different versions of a gene



Sequence for normal adult hemoglobin:

Nucleotide CTG ACT CCT GAG GAG AAG TCT

Wild-type Hemoglobin Protein

Normal Red Blood Cell

Sequence for mutant hemoglobin:

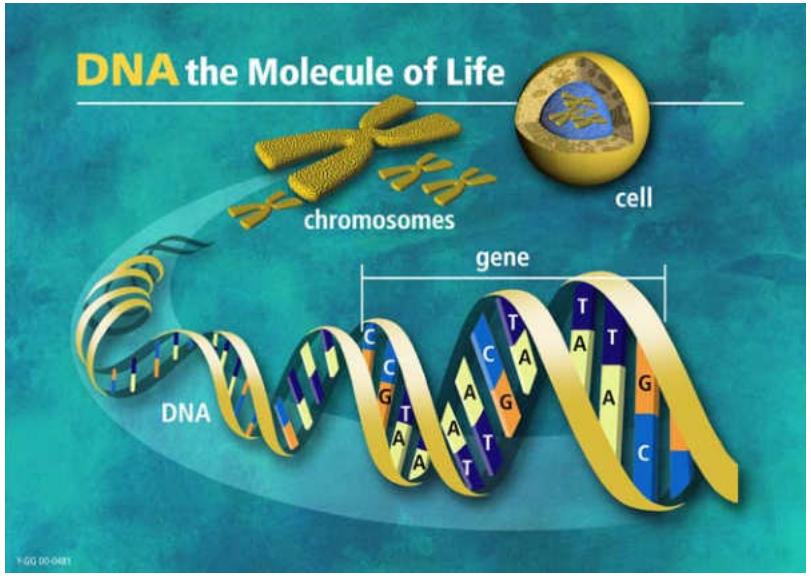
Nucleotide CTG ACT CCT GTG GAG AAG TCT

Mutant Protein

Abnormal Red Blood Cell

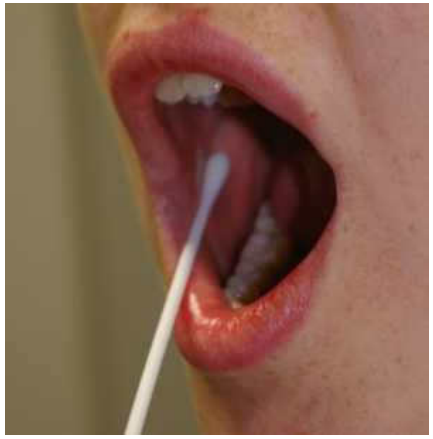
The Human Genome Project Goals

- To sequence (i.e. determine the exact order of nucleotides (A,T,G,C) for ALL of the DNA in a human cell
- To determine which sections of DNA represent individual genes (protein-coding units).



The HGP: International effort to decipher the blueprint of a human being.

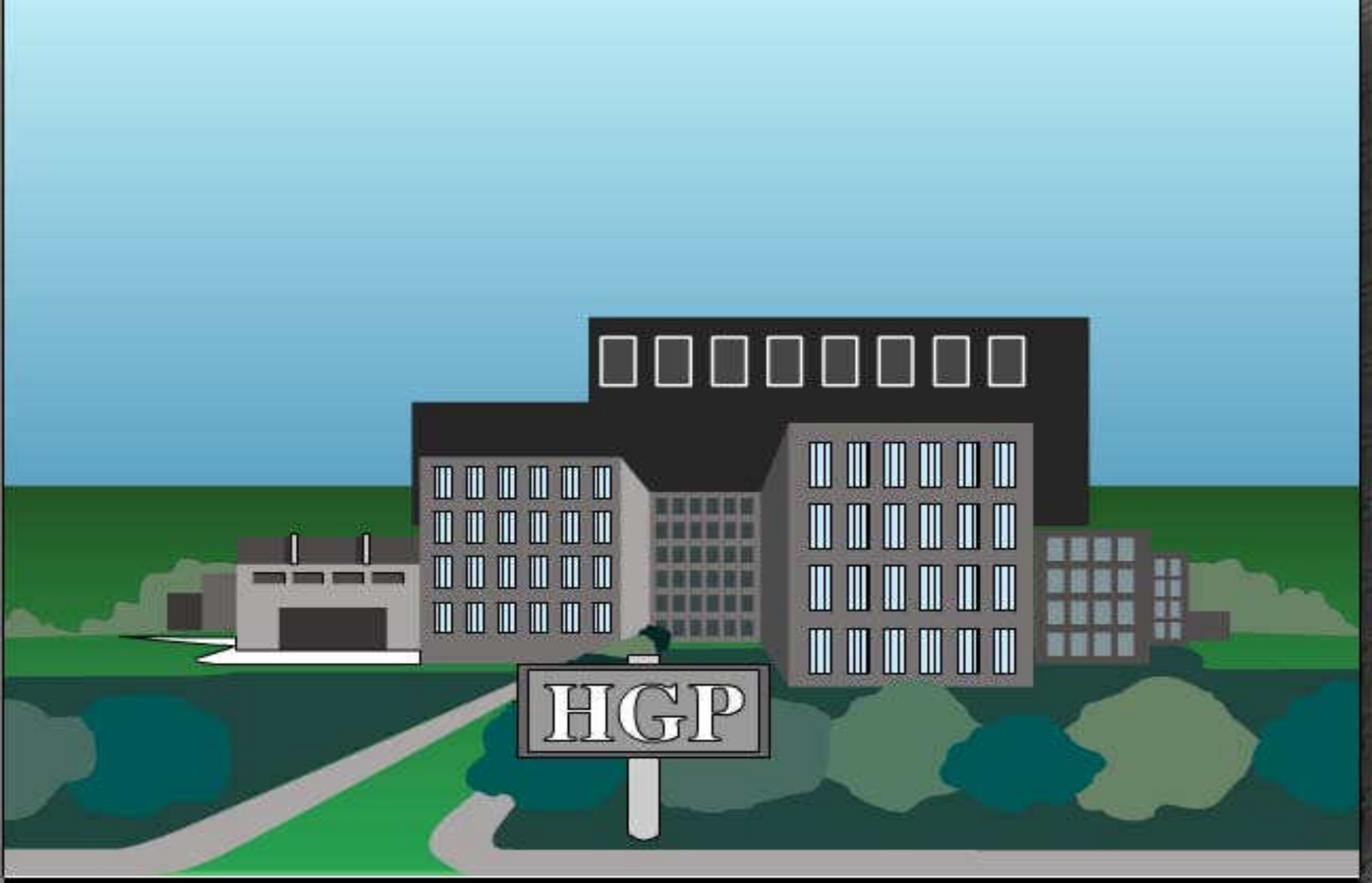
How It Was Done



DNA samples collected from thousands of volunteers

Samples sent to Human Genome Project centers across the world

Scientists at centers perform DNA sequencing and analysis

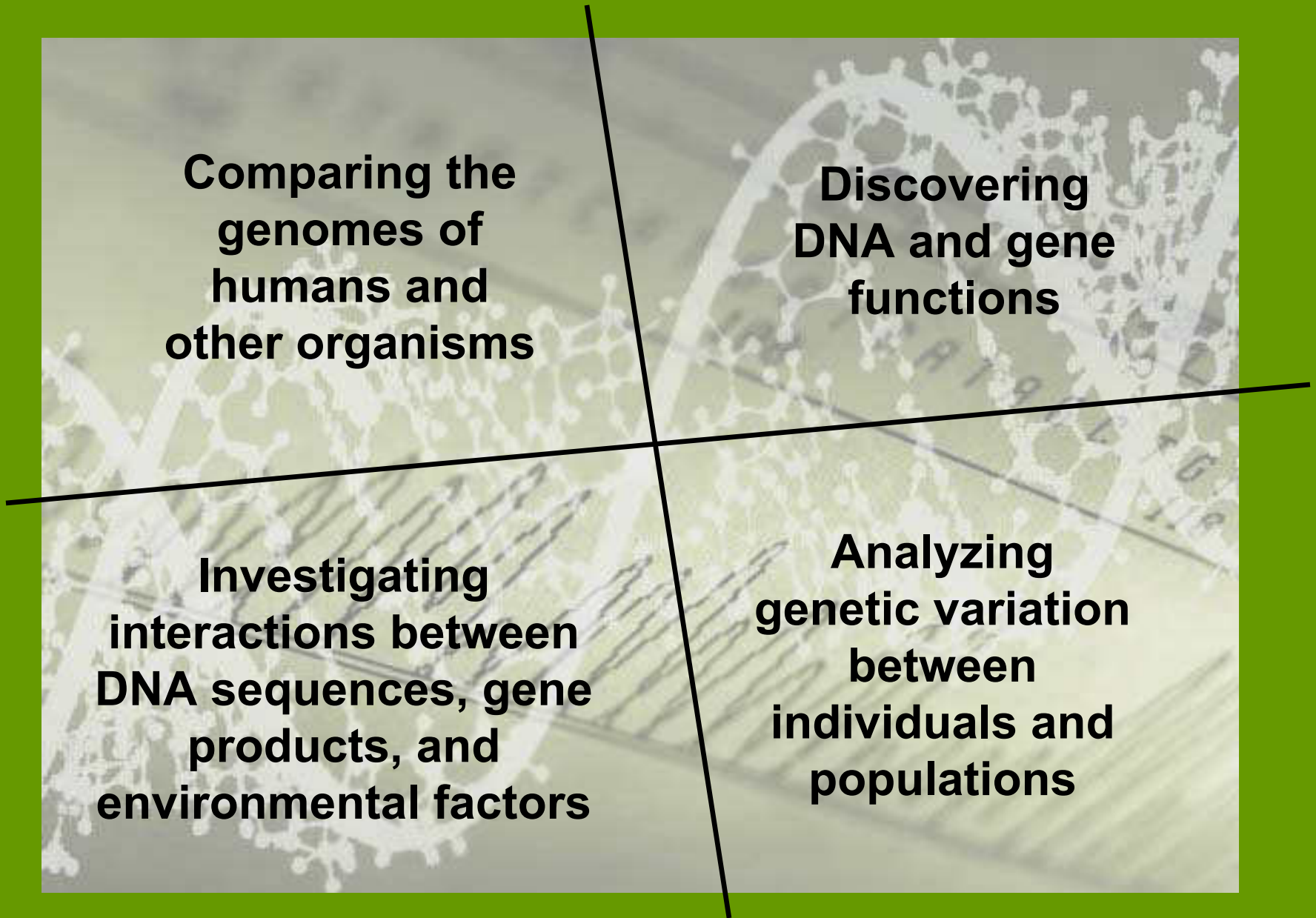


Whenever a stretch of DNA that spanned 2,000 or more bases was assembled, it was placed into public databases within 24 hours. Anyone with access to the Internet could see and analyze the sequence data.

- **February 2001: Draft of the sequence published in Nature (public effort)and Science (Celera – private company).**

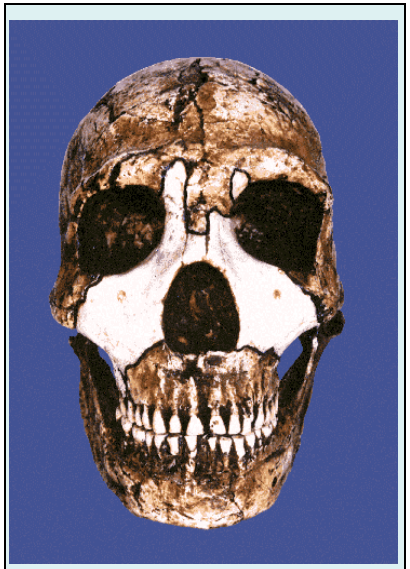
- **April, 2003 (50 years after Watson and Crick structure of DNA was published) : Full sequence published and researchers determined that within this sequence there was somewhere between 30,000 and 40,000 genes. We now believe there are closer to 25,000 genes**

Still A Lot of Work To Do . . .



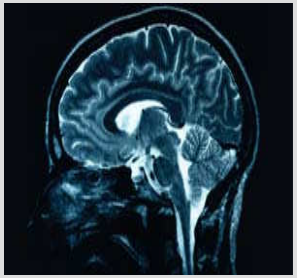
How Can We Use This Information?

Better understanding of human disease



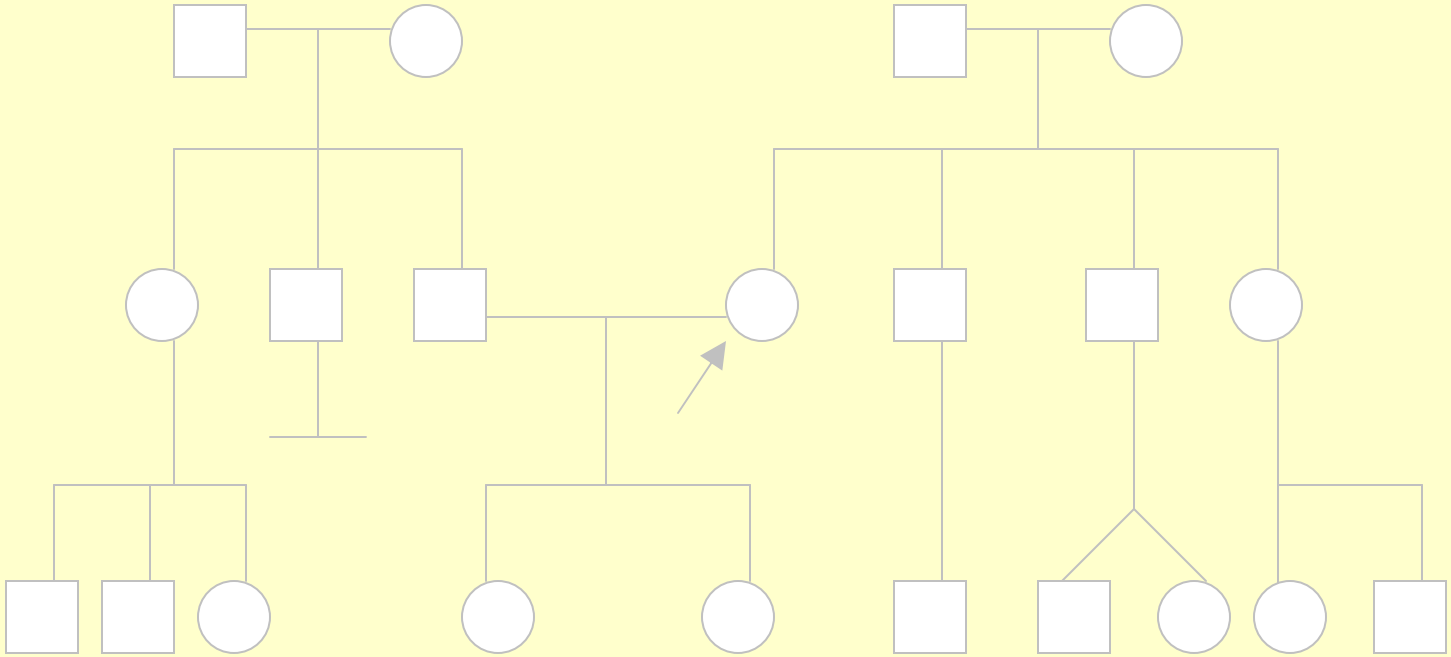
Insight into human origins

Personalized medicine & Pharmacogenetics



Greater insight into cognitive function

Identifying genetic susceptibility to disease



Inheritance of Genes





Gregor Mendel

1822-1884

Picture from www.nih.nlm.gov

- Augustinian monk who cross-bred pea plants with different characteristics
- Observations led to laws regarding the transmission of hereditary characteristics from generation to generation
- Many of the concepts from his observations still hold true today!

Mendel's Laws:

1. Principle of Segregation: Two members of a gene pair segregate from each other in the formation of gametes; half the gametes carry one allele, and the other half carry the other allele

   What it means: each gene has two copies (alleles) and a parent will give only one copy to a child. The other parent will give another copy, and thus the child will receive two copies (alleles) – one from each parent. Each child will literally be half-mom and half-dad!

Mendel's Laws:

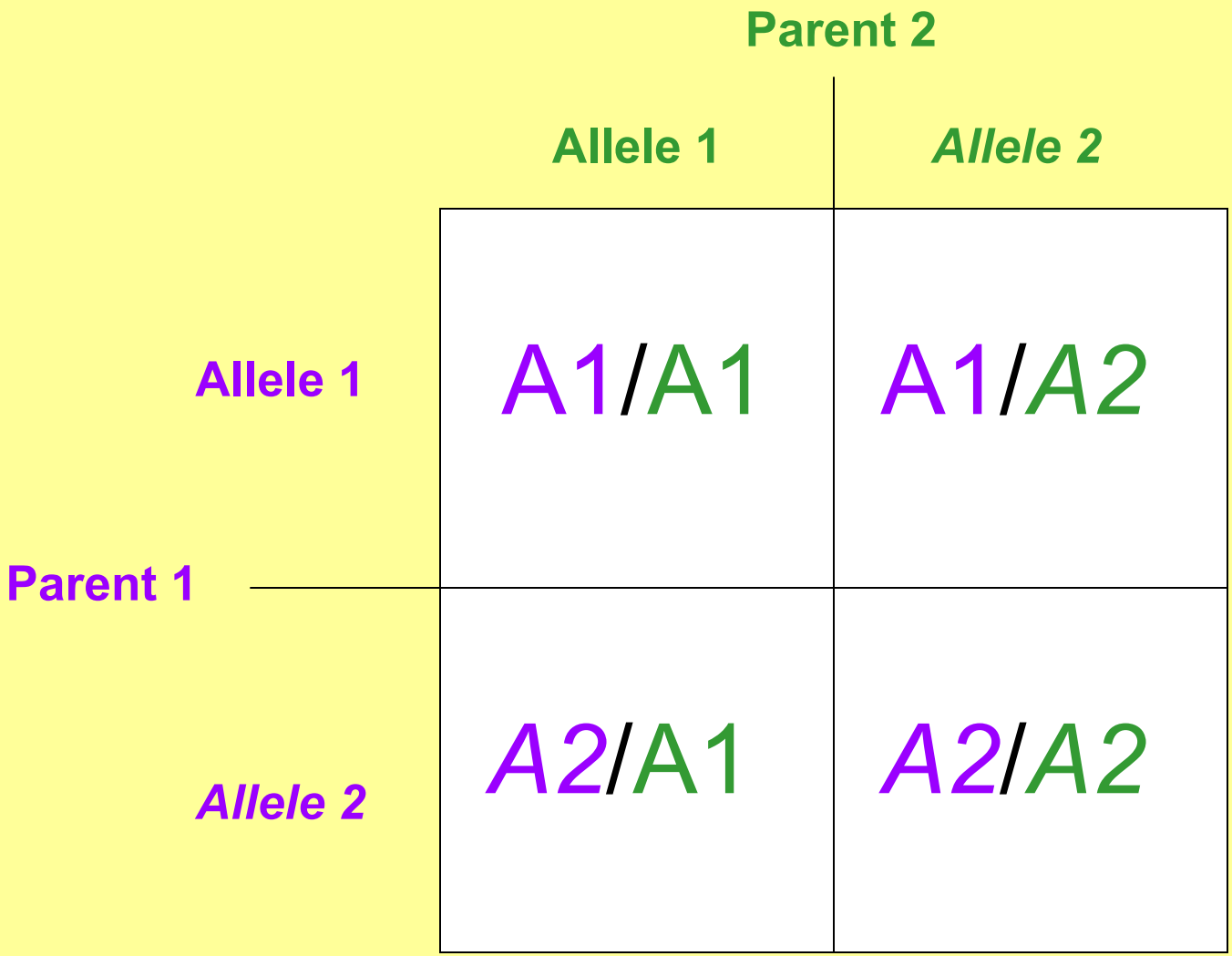
2. Principle of Independent Assortment: Genes for different traits assort independently of one another in gamete production

   What it means: different genes are inherited separately. For example, the gene which codes for eye color is inherited separately from the gene which codes for nose shape.

Mendelian Concepts

- Dominant = only one allele of a gene necessary to express the trait
- Recessive = both alleles of a gene must be identical to express the trait
- Heterozygous = alleles of a particular gene are non-identical
- Homozygous = alleles of a particular gene are identical

Applying Mendelian Concepts:
The Punnett Square



Homozygous dominant + Homozygous dominant

	A	A
A	AA	AA
A	AA	AA

Homozygous dominant + Heterozygous

	A	A
A	AA	AA
a	Aa	Aa

Homozygous dominant + Homozygous recessive

	a	a
A	Aa	Aa
A	Aa	Aa

Heterozygous + Heterozygous

	A	a
A	AA	Aa
a	Aa	aa

EXAMPLE

- Dan and Kim are going to have a baby. Kim has dimples in her cheeks (a dominant trait), while Dan does not.
- What are the chances Dan and Kim's baby will have dimples?

We know Dan and Kim's phenotypes (no dimples/dimples), but what are their genotypes?

- Dan has the recessive trait (no dimples)
  - He must have two recessive alleles
  - Dan's genotype can be represented as 'dd'
- Kim has the dominant trait (dimples)
  - But Kim could be homozygous dominant OR heterozygous dominant
  - Kim's genotype can be either 'DD' or 'Dd'
  - Which one is it?

More information

- What if you knew something about Kim’s parents?
- How could that help?

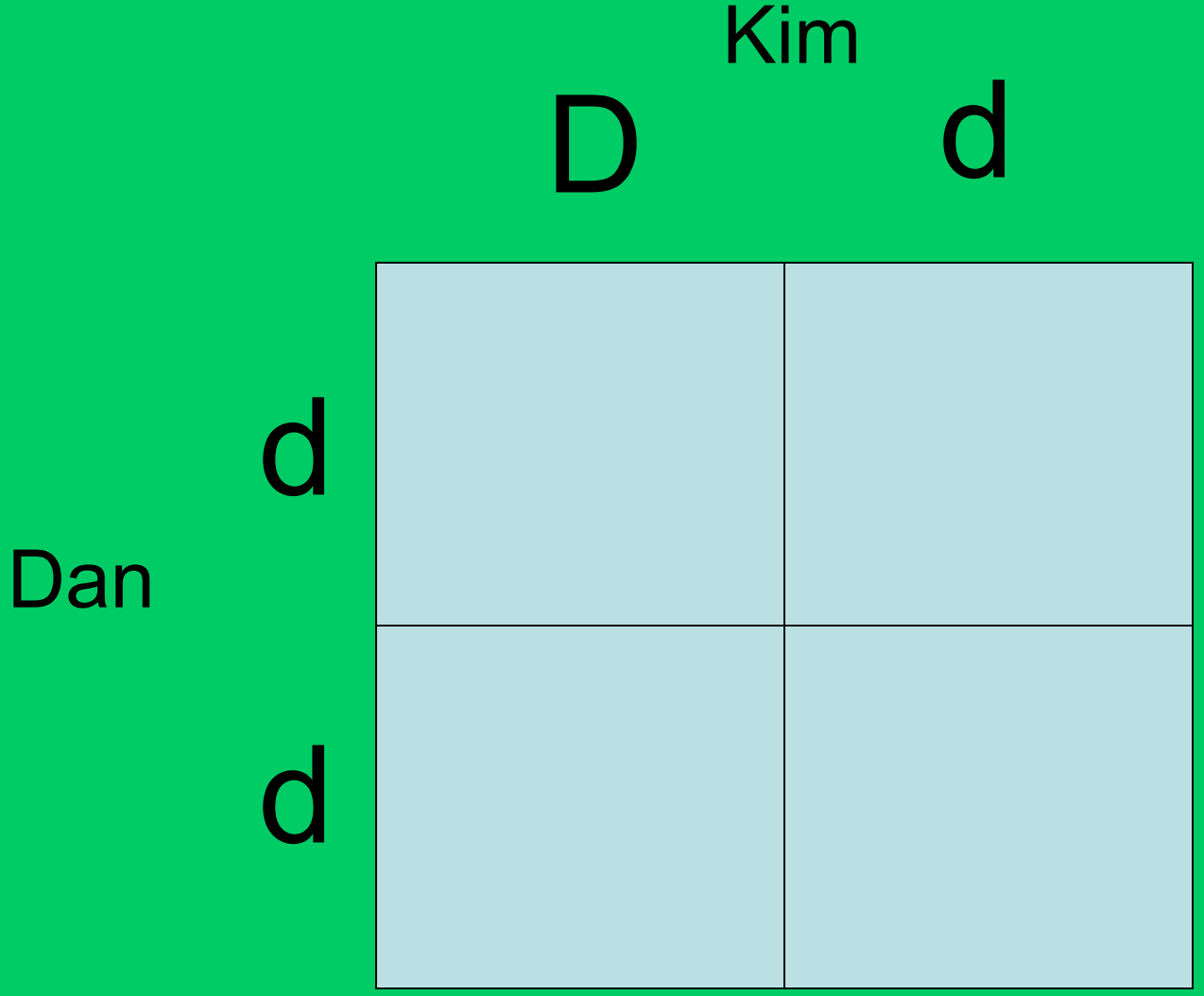
Kim's Parents

- As it turns out, Kim's father has dimples in both cheeks, while her mother does not
- Her mother must have the recessive trait and therefore has to have the genotype 'dd'
- Kim's father has the dominant trait, but we don't know if he is a homozygote or heterozygote. He could be 'DD' or 'Dd' just like Kim!
- But we still know what Kim's genotype must be. Why?

Kim's genotype is 'Dd'

- Kim must have a recessive allele (d), since that is all she could have inherited from her mother
- Since Kim has dimples, we know she inherited a dominant allele (D) from her father
  - It doesn't matter if Kim's father is DD or Dd; whichever it is, he passed on a 'D' to his daughter

What are the chances Kim and Dan's baby will have dimples?



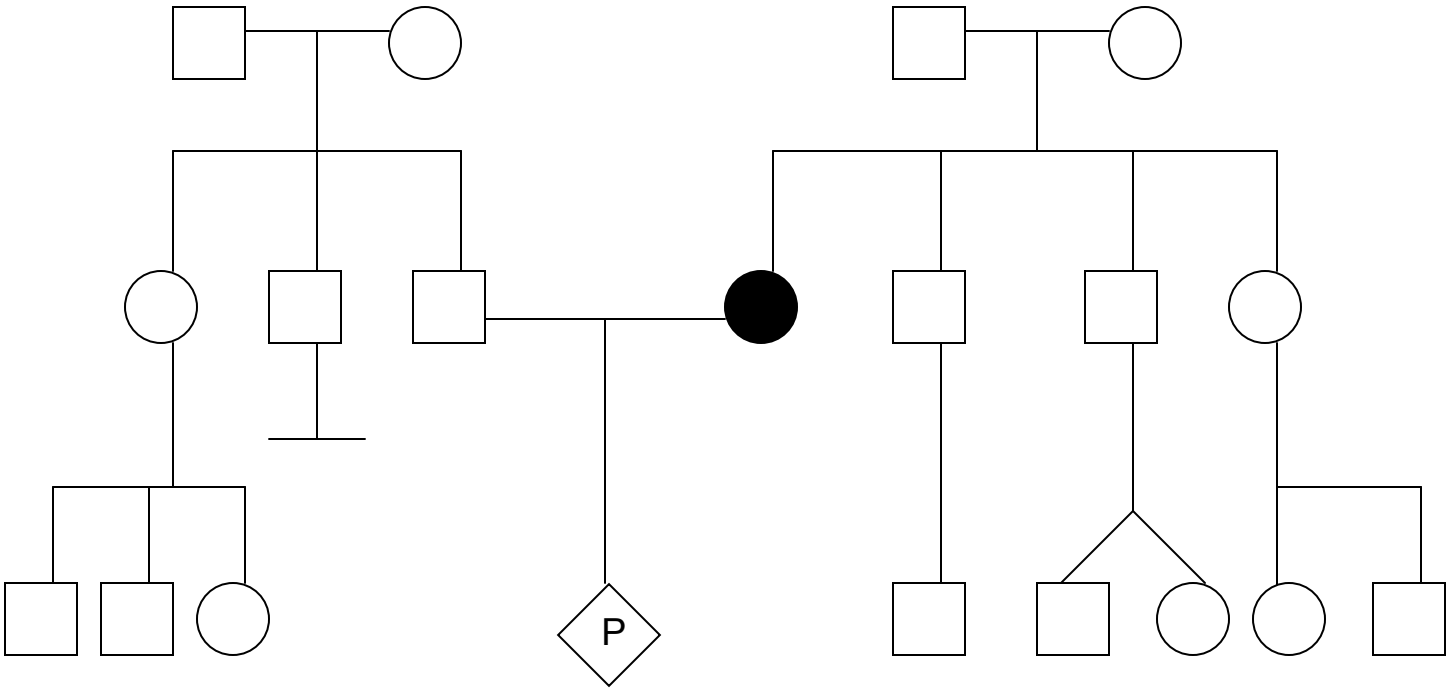
Kim

Dan	D	d
d	Dd	dd
d	Dd	dd

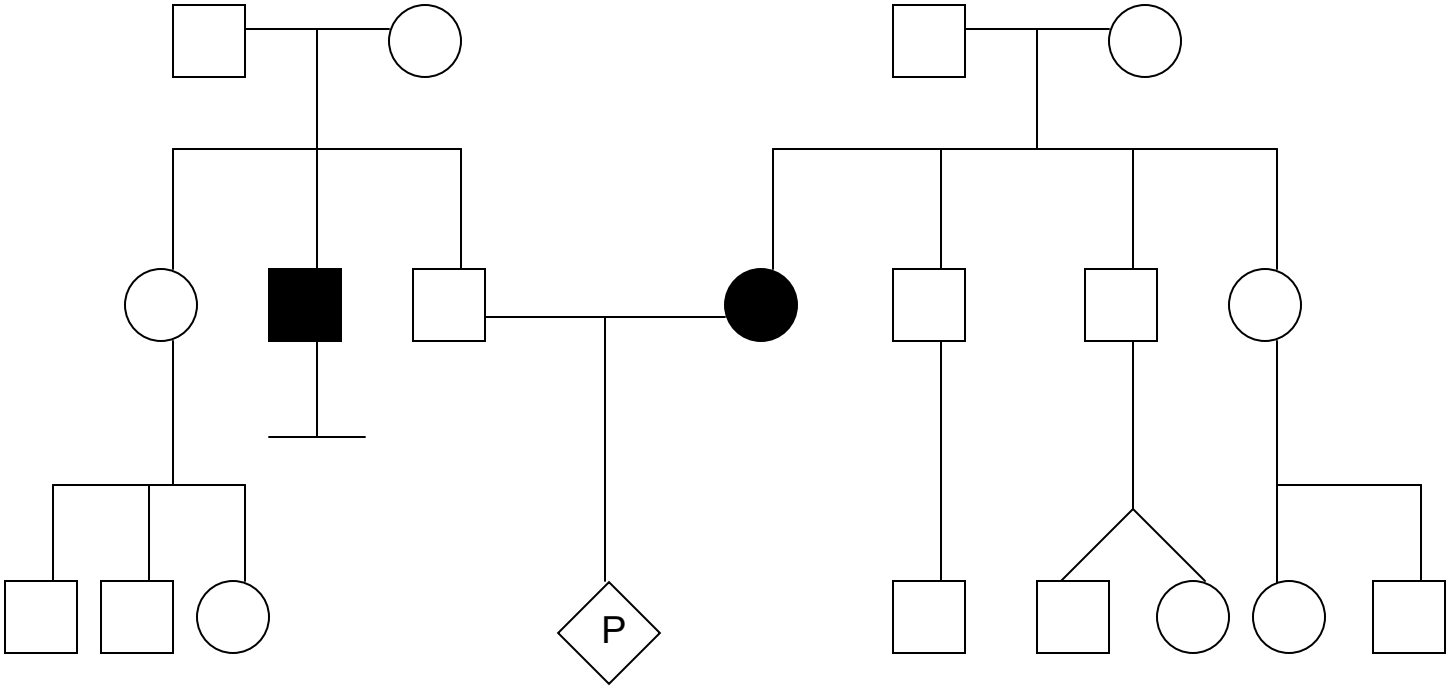
50% chance the baby will have the genotype ‘Dd’ and have dimples

50% chance the baby will have the genotype ‘dd’ and not have dimples

Clinical Application



Clinical Application continued . . .



Other things may change us, but we start and end with family

-Anthony Brandt

If you look deeply into the palm of your hand, you will see your parents and all generations of your ancestors. All of them are alive in this moment. Each is present in your body. You are the continuation of each of these people.

-Thich Nhat Hanh


Questions?

Adapted from a Presentation Created by the University of North Carolina DNA Day Program

- Sponsors
  - NC Glaxo Smith Kline Foundation
  - National Human Genome Research Institute
  - Sigma XI Scientific Research Society
- Collaborative Partners
  - North Carolina Department of Public Instruction
  - Destiny Traveling Science Learning Program
  - North Carolina Association for Biomedical Research
  - National Human Genome Research Institute
  - American Society for Human Genetics
- North Carolina Educators
  - Amy Bradley, Hibriten High School; Cindy Byron, School of Inquiry and Life Sciences at Asheville (SILSA); Anita Crowley, Lee County High School; MaryAnne Gore, West Brunswick High School; Terry Howerton, The School of Biotechnology at Atkins; Michael Kendall, East Bladen High School; Crystal McDowell; Letitia Myles, E.E. Smith High School; Elizabeth Pressley, Bartlett Yancey High School; Steven Ross, Harnett Central High School; Murphey Wellman, North Iredell High School; Anita Willington, East Bladen High School; Linda Woody, Reidsville High School