## Practical and Ethical Issues in Genetics for Everyday Life

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> Shepherds 360 Conference, Ethics Vol. 2 17 October 2023



#### Disclaimer

- My views do not represent:
  - My employer Duke School of Medicine or Duke University as a whole
  - My funding agency National Institutes of Health
  - Any of the institutions where I trained
- I will be presenting a scientific perspective today to stimulate biblical thinking about genetics and medicine

#### **Outline for today's talk**



#### The basics of DNA and the genome

#### The Human Genome Project

"What if..." scenarios

## The Tool God Used in Creation: DNA

- DNA is the language God used when creating life
- Instructions or code for human development, cellular function, growth, health
- 4 chemical letters called nucleotides (A, C, G, T) create the DNA polymer
- Genome = complete set of DNA and code instructions
- 6 billion A-C-G-Ts in each cell
- 6 feet of DNA is packaged into each cells



#### **Genome: All the DNA in the Cell**



The genome is the book of all our DNA. The A-C-G-Ts are the alphabet that is used in the genome "book".

#### The Genome: The Book of Biological Life

...AGCTTCAGGCGGCTGCGACGAGCCCTCAGGCGAACCTCTCGGCTTTCCCGCG CGGCGCCGCCTCTTGCTGCGCCTCCGCCTCCTCCTCCGCCACCGGCTTCC TCCTCCTGAGCAGTCAGCCCGCGCGCCGGCCGGCTCCGTTATGGCGACCCGCA GCCCTGGCGTCGTGGTGAGCAGCTCGGCCTGCCGGCCCTGGCCGGTTCAGGCC CACGCGGCAGGTGGCGGCCGGGGCCCTGAGGCGCGGGGATCCGCAGTGCGGGCT GTTCGGCTTTACGTCACGCGAGGGCGGCAGGGAGGACGGAATGGCGGGGTTT GGGGTGGGTCCCTCCTCGGGGGGGGCCCTGGGAAAAGAGGACTGCGTGTGGG AAGAGAAGGTGGAAATGGCGTTTTGGTTGACATGTGCCGCCTGCGAGCGTGC TGCGGGGAGGGGCCGAGGGCAGATTCGGGAATGATGGCGCGGGGTGGGGG CGTGGGGGCTTTCTCGGGAGAGGCCCTTCCCTGGAAGTTTGGGGTGCGATGGT GAGGTTCTCGGGGCACCTCTGGAGGGGCCTCGGCACGGAAAGCGACCACCTG GGAGGGCGTGTGGGGGACCAGGTTTTGCCTTTAGTTTTGCACACACTGTAGTTC ATCTTTATGGAGATGCTCATGGCCTCATTGAAGCCCCACTACAGCTCTGGTAGC GGTAACCATGCGTATTTGACACACGAAGGAACTAGGGAAAAGGCATTAGGTC ATTTCAAGCCGAAATTCACATGTGCTAGAATCCAGATTCCATGCTGACCGATGC CCCAGGATATAGAAAATGAGAATCTGGTCCTTACCTTCAAGAACATTCTTAACC GTAATCAGCCTCTGGTATCTTAGCTCCACCCTCACTGGTTTTTCTTGTTGTTG ATAGTCAAAACCCCGGCCAGTTAAATATGCTTTAGCCTGCTTTATTATGATTAT TTTTGTTGTTTGGCAATGACCTGGTTACCTGTTGTTTCTCCCACTAAAACTTTT AAGGGCAGGAATCACCGCCGTAACTCTAGCACTTAGCACAGTACTTGGCTTGT AAGAGGTCCTCGATGATGGTTTGTTGAATGAATACATTAAATAATTAACCACTT GAACCCTAAGAAAGAAGCGATTCTATTTCATATTAGGCATTGTAATGACTTAA GGTAAAGAGCAGTGCTATTAACGGAGTCTAACTGGGAATCCAGCTTGTTTGGG CTATTTACTAGTTGTGTGG...

GENES = Groups of letters are words and sentences

Letters in book = DNA

#### The Genome: The Book of Biological Life

...AGCTTCAGGCGGCTGCGACGAGCCCTCAGGCGAACCTCTCGGCTTTCCCGCG CGGCGCCGCCTCTGCTGCGCCTCCGCCTCCTCCTCCGCCACCGGCTTCC TCCTCCTGAGCAGTCAGCCCGCGCGCCGGCCGGCTCCGTTATGGCGACCCGCA GCCCTGGCGTCGTGGTGAGCAGCTCGGCCTGCCGGCCCTGGCCGGTTCAGGCC CACGCGGCAGGTGGCGGCCGGGCCCTGAGGCGCGGGATCCGCAGTGCGGGCT GTTCGGCTTTACGTCACGCGAGGGCGGCAGGGAGGACGGAATGGCGGGGTTT GGGGTGGGTCCCTCCGGGGGGGGCCCTGGGAAAAGAGGACTGCGTGTGGG AAGAGAAGGTGGAAATGGCGTTTTGGTTGACATGTGCCGCCTGCGAGCGTGC TGCGGGGAGGGGCCGAGGGCAGATTCGGGAATGATGGCGCGGGGTGGGGG CGTGGGGGCTTTCTCGGGAGAGGCCCTTCCCTGGAAGTTTGGGGTGCGATGGT GAGGTTCTCGGGGCACCTCTGGAGGGGCCTCGGCACGGAAAGCGACCACCTG GGAGGGCGTGTGGGGGACCAGGTTTTGCCTTTAGTTTTGCACACACTGTAGTTC ATCTTTATGGAGATGCTCATGGCCTCATTGAAGCCCCACTACAGCTCTGGTAGC GGTAACCATGCGTATTTGACACACGAAGGAACTAGGGAAAAGGCATTAGGTC ATTTCAAGCCGAAATTCACATGTGCTAGAATCCAGATTCCATGCTGACCGATGC CCCAGGATATAGAAAATGAGAATCTGGTCCTTACCTTCAAGAACATTCTTAACC ATAGTCAAAACCCCGGCCAGTTAAATATGCTTTAGCCTGCTTTATTATGATTAT TTTTGTTGTTTTGGCAATGACCTGGTTACCTGTTGTTTCTCCCACTAAAACTTTTT AAGGGCAGGAATCACCGCCGTAACTCTAGCACTTAGCACAGTACTTGGCTTGT AAGAGGTCCTCGATGATGGTTTGTTGAATGAATACATTAAATAATTAACCACTT GAACCCTAAGAAAGAAGCGATTCTATTTCATATTAGGCATTGTAATGACTTAA GGTAAAGAGCAGTGCTATTAACGGAGTCTAACTGGGAATCCAGCTTGTTTGGG CTATTTACTAGTTGTGTGG...



- The instructions in the book are used to generate PROTEINS
- PROTEINS are ON and OFF switches in our cells
- Mutation changes the DNA (i.e. words in the book)

ACTCCCTCTACCACCTTACCACTACTCCATCACCCCTA **ICCCTCTCCCCTATATATACCCCTCTCTCTCTTTTT PCAGATCCCATACTCATCCTTCTACCCCATCCAACCCT** CETACEACEATCEATTTCTCTCACATETEAATATEETC PATCCACATCTCTCCCCCCCCATATAATATCCACACTC CACCCATCATCTACACTACCTACACACCCACTCAACAC ATCCTACCACACCTCACCCTATATCCTCCTATCCACCC PAACCCCCTACTCCCCTACTCACTCACTATCCCCCCCC ACCCCCCATATCCCCCATCTCCCCTCATATCCCATCC CCCTAATACTACTATCATTATAATCCCTACACCTAAAA PACCAACCCCCTAATATCCTACCAAACTCTATCATTA **TCATACTAATTATAACTAATACTCCCCATATCCCCAT** ATATCCACCCATATITCCATACCACAAACTCACTACC ATACTAACTCACTAATCACTACCCACTACTCACCTACT ACTACTCATCACTCACCACCACATCATTCTACTCTCT ACTCTATCTACCATCCCTACCTACCTCCTTATCCTACT PACTCACATACTACTCATTACTCACTACTCACTCACTCAATC <u> PATCATTTCAATTTCCCCCCTCTATCATCATCATCATCA</u> **FCCACCTCACTACCTACCATCACCCCCTACCCAT** CATCAACTATACTATCATCATCGTACCCCCCCCCCTT ATACTACTACTCCATCCATCCATCACCCCCGTCCAT PACTCCATTTTCCATCCTCACTCCATCCATCACTCCAT CCTACTCACAACCTCCATCCCCACTCACTCACTCACTC CTCATCCTCCATCCATCCACTACTTCATACTA/ CTACCACGTACGCCATCCTCTACCTACATATCCTACCI TCACTCCCATATATACCCCATAACACCCCCCCTCTCI CATCAGTCTACTACTCCCACTACCTACAAACCATCACI

#### **The Human Genome Project**

- Started in 1990 as an international effort
- Entire book of DNA (genome) from a few individuals was sequenced
- Goals were to:
  - 1. IDENTIFY every A-C-T-G in human cells
  - 2. MAP all the genes and their control elements
  - 3. DECIPHER the code what do genes do?
  - 4. CORRELATE gene mutations to disease
  - 5. DIAGNOSE and PREDICT disease
  - 6. DEVELOP treatments for disease
  - 7. COMPARE genetic differences among people
- Human genome finally complete in April 2022

# What has the Human Genome Project told us?

- Humans have 20,000 genes
- DNA content between humans is 99.9% similar
- Each of our genomes differ by 3 million A-C-G-Ts
- The words (gene) and the structure of our sentences (DNA sequence) in each of our "DNA books" make us unique biologically

### Genetic Information is Being Used in Medical Care and Treatment



#### Current & Future

More Personalized Diagnostics



# Should a Christian do...?

### **Should a Christian do Ancestry Testing?**



- Ancestry testing = genetic genealogy
- Gives molecular/DNA view of a person's ancestors
- Variation in DNA sequence clusters in global regions
- Ancestry testing can include:
  - Y chromosome (male information)
  - Mitochondrial DNA (female information)
  - Autosomal (non-sex chromosomes, i.e., X or Y)
    - Scans single nucleotide polymorphisms (SNPs) or single nucleotide variants (SNVs)
    - 500,000 1,000,000 sites of DNA variation are tested

## Should a Christian do Ancestry Testing?

#### • This is an area of Christian liberty

- Ancestry testing is not inherently wrong
- Ancestry testing speaks to our ethnic heritage over time
- If Ancestry testing is done, how we mentally process results dmatters...
- We are created in God's image (Gen. 1)
- We biologically trace back to our original earthly parents Adam & Eve
- Our identity is in Christ (1 Cor. 3:23)
- Our present and future are rooted in belonging to the family of God (Rom. 8:16-17; Gal. 3:29 – 4:7)



# Should Christians use pharmaceutical drugs produced by genetic engineering?



- Human insulin gene inserted into bacteria or yeast
- Bacteria/Yeast grow fast so loads of insulin are produced quickly
- Human insulin is purified away from bacterial or yeast proteins and packaged for clinical use
- Less expensive and can be scaled for demand

# Should Christians use pharmaceutical drugs produced by genetic engineering?



#### This is an area of Christian liberty

- Isolating human proteins from bacteria or yeast in a controlled lab setting is ethical and safe
- Not economical to isolate insulin from pigs and cows
- Risk of allergic reactions to pig and cow proteins
- Current research: to make humanized pigs that have human insulin for islet cell transplants

## Should Christians eat GMO foods?



- Apples ripen through activity of polyphenol oxidases (PPOs)
- PPOs react with oxygen to cause apples to brown
- Genetic engineering technique, called RNA interference (RNAi), controls the activity of PPO genes
- RNAi = a "restrictor plate" for the PPO genes' "engine"
- Genetic engineering of fruits, vegetables, livestock often uses their own DNA

## Should Christians eat GMO foods?



#### This is an area of Christian liberty

- Selecting for traits is done naturally by cross-breeding but is slow
- Swapping genes from one vegetable to another (soybean) to sweet potato is a "same kind" experiment
- Oswapping genes from animals to plants and vice versa could be considered "not the same kind"
- How GMOs are made and materials used matters (viral vectors, allergenic proteins)



# Should a Christian get genetic testing?

- To diagnose or confirm disease
- To aid in treatment of disease
- For reproductive purposes and/or prenatal diagnosis
  - Does my unborn child have a disease?
  - Why can't I get pregnant?
  - Am I a carrier of a genetic disease?

#### Genetic testing can be done at different life stages

#### Timing of Genetic Testing



- Genetic testing is not inherently unethical or unbiblical
- The purpose of the testing and what will be done with the results is what matters
- This is an area of Christian liberty



# Should a Christian Get Therapies or Treatments that Involve Genetic Engineering?

CRISPR-mediated CAR-T cell therapy of somatic cells to more effectively treat cancer



somatic cell genome engineering can safely and effectively be used for targeted treatment without changing the entire genome of the individual

#### Points to ponder about DNA, Genetics, and Medicine

- God created DNA and organized every genome
- God designed how life is created and sustained
  - procreation through marriage between a man and a woman (GENETICS)
  - unborn is a person from the moment of conception
- God graced humans with intellect to think, discover, work
- "Genetic/medical technology is God's gift to counter the effects of sin. Medicine can be the use of God's gift of knowledge, reason, and wisdom." – *M. Foreman and L. Leonard in "Christianity and Modern Medicine"*

#### A Biblical View of DNA, Genetics, and Medicine

- One's motivations should be carefully and biblically considered
- WHAT ARE YOU THINKING AND WANTING?
- Will my decision honor God as Creator and Sovereign?
- Will my decision minimize suffering?
- Will my decision reflect Christ and serve others?
- The culture should not dictate our choices
- **Biblical principles** should guide our decisions

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