Geneticist's Curriculum

(Vol.1)

This curriculum is designed to be an as-available approach to becoming a geneticist. This curriculum is prepared under the assumption of genuine interest for the field. The meaning of life (for humans) is fun productivity. If your ideal life consists of a fun and productive career in one (or more) of the many fields of genetics: this curriculum is the single best resource on the planet for attaining that aim through self-education. If you are not excited about anything concerning the subject of genetics, there is a chance your true interests lay elsewhere. Your ideal career will be a job you can't wait to get to in the morning (or night). Your dream career is one that you'd do for fun if you possessed unlimited wealth. If that's the case with genetics, please see below:

The material below is presented in no particular order. Pick whichever is the most interesting to you and start there. As you learn the fundamentals of "the cool stuff", the less interesting material becomes more interesting as you begin to see its relevance. Don't worry about the subjects that seem daunting. As you learn more, hesitation will become interest. Then curiosity.

Geneticist's Curriculum consists of material from free or commercially available online sources.

Audio Courses & Audiobooks

All material currently **available at www.audible.com** [x3 speed encouraged]

The underlining is for ease of navigating the list, and has no relevance concerning content.

1. Understanding Genetics: DNA, Genes, and Their Real-World Application (David Sadava)
2. Biology: The Science of Life (Stephen Nowicki)
3. The Compatibility Gene: How Our Bodies Fight Disease, Attract Others, and Define Our Selves (Daniel M. Davis)
4. The Epigenetics Revolution (Nessa Carey)
5. Brain in Balance: Understanding the Genetics and Neurochemistry behind Addiction and Sobriety (Fredrick Von Stieff)
6. Stress and Your Body (Robert Sapolsky)
7. Life Unfolding: How the Human Body Creates Itself (Jamie A. Davies)
8. Mind-Body Medicine: The New Science of Optimal Health (Jason M. Satterfield)
9. Periodic Tales: A Cultural History of the Elements, From Arsenic to Zinc (Hugh Aldersey Williams)
10. Memory and Human Lifespan (Steve Joordens)
11. The Addictive Brain (Thad A. Polk)
12. Understanding the Secrets of Human Perception (Peter Vishton)
13. Life's Greatest Secret: The Race to Crack the Genetic Code (Matthew Cobb)
14. The Genius in All of Us: Why Everything You've Been Told About Genetics, Talent, and IQ is Wrong (David Shenk)
15. Secrets of Sleep Science: Dreams To Disorders (Craig Heller)
16. Medical School for Everyone: Grand Round Cases (Roy Benaroch)
17. The Philadelphia Chromosome: A Mutant Gene and the Quest to Cure Cancer at the Genetic Level (Jessica Wapner)
18. The Basics of Genetics (Betsey Dexter Dyer)
19. Epigenetics: The Ultimate Mystery of Inheritance (Richard C. Francis)
20. How We Learn (Monisha Pasupathi)
21. Brain Maker (David Perlmutter, Kristin Loberg)
22. Sensation, Perception, and the Aging Process (Francis B. Colavita)
23. The Longevity Seekers: Science, Business, and the Fountain of Youth (Ted Anton)
24. An Introduction to Infectious Diseases (Barry C. Fox)
25. The Joy of Science (Robert M. Hazen)
26. Forensics: What Bugs, Burns, Prints, DNA, and More Tell Us About Crime (Val McDermid)
27. The Violinist's Thumb: And Other Lost Tales of Love, War, and Genius, as Written by Our Genetic Code (Sam Kean)
28. Life's Ratchet: How Molecular Machines Extract Order from Chaos (Peter M. Hoffman)
29. Louder Than Words: The New Science of How the Mind Makes Meaning (Benjamin K. Bergen)
30. Consciousness and the Brain: Deciphering How the Brain Codes Our Thoughts (Stanislas Dehaene)
31. Drugged: The Science and Culture Behind Psychotropic Drugs (Richard J. Miller)
32. Origins of the Human Mind (Stephen P. Hinshaw)
33. Stuff Matters (Mark Miodownik)
34. Understanding the Mysteries of Human Behavior (Mark Leary)
35. Incomplete Nature: How Mind Emerged from Matter (Terrence W. Deacon)
36. Just Babies: The Origins of Good and Evil (Paul Bloom)
37. Why Evolution is True (Jerry A. Coyne)
38. The Patient Will See You Now: The Future of Medicine is in Your Hands (Eric Topol, MD)
39. Genome: The Autobiography of a Species in 23 Chapters (Matt Ridley)
40. DNA: The Secret of Life (James Watson, Andrew Berry)
41. The Red Queen: Sex and the Evolution of Human Nature (Matt Ridley)
42. The Deeper Genome: Why There is More to the Human Genome than Meets the Eye (John Parrington)
43. Life on the Edge: The Coming of Age of Quantum Biology (Johnjoe McFadden, Jim Al-Khalili)
44. How to Build and Android (David F. Dufty)
45. Radical Abundance: How a Revolution in Nanotechnology will Change Civilization (K. Eric Drexler)
46. On Intelligence (Jeff Hawkins, Sandra Blakeslee)
47. Virtually Human: The Promise – and the Peril – of Digital Immortality (Martine Rothblatt)
48. Evolving Ourselves (Juan Enriquez, Steve Gullans)
49. The 4th Revolution: How the Infosphere is Reshaping Human Reality (Luciano Floridi)
50. Intertwingled: Information Changes Everything (Peter Morville)
51. NeuroTribes: The Legacy of Autism and the Future of Neurodiversity (Steve Silberman)
52. Feathers: The Evolution of a Natural Miracle (Thor Hanson)
53. The Reason for Flowers: Their History, Culture, Biology, and How They Change Our Lives (Stephen Buchmann)
54. The Modern Scholar: The Biology of Birds (John Kricher)
55. The Modern Scholar: Unseen Diversity: The World of Bacteria (Betsey Dexter Dyer)
56. The Science of Cheese (Michael H. Tunick)

57. Science of Self (Lee M. Silver)
58. The Stem Cell Hope: How Stem Cell Medicine Can Change Our Lives (Alice Park)
59. Missing Microbes: How the Overuse of Antibiotics is Fueling Our Modern Plagues (Martin J. Blaser)
60. Domesticated: Evolution in a Man-Made World (Richard C. Francis)
61. Biology and Human Behavior: The Neurological Origins of Individuality (Robert Sapolsky)
62. The Language of Life: DNA and the Revolution in Personalized Medicine (Francis S. Collins)
63. The Gene: An Intimate History (Siddhartha Mukherjee)
64. The Digital Doctor: Hope, Hype, and Harm at the Dawn of Medicine's Computer Age (Robert Wachter)
65. Genes, Chromosomes, and Disease: From Simple Traits to Complex Traits to Personalized Medicine (Nicholas Wright Gillham)
66. Your Inner Fish: A Journey Into the 3.5 Billion-Year History of the Human Body (Neil Shubin)
67. Orphan: The Quest to Save Children with Rare Genetic Disorders (Philip R. Reilly)
68. Winter World: The Ingenuity of Animal Survival (Bernd Heinrich)
69. She Has Her Mother's Laugh: The Powers, Perversions, and Potential of Heredity (Carl Zimmer)
70. Who We Are and How We Got Here (David Reich)
71. Life's Engines: How Microbes Made Earth Habitable (Paul G. Falkowski)

YouTube

(Material **available at www.youtube.com**)

CRASH COURSE – YouTube Channel

1. BIOLOGY (There are **40 courses** on this Playlist – all of which are essential. Below are the ones you should pay special concentration to)
    a. 3 – Biological Molecules – You Are What You Eat
    b. 4 – Eukaryopolis – The City of Animal Cells
    c. 5 – In The Club – Membranes & Transport
    d. 6 – Plant Cells
    e. 9 – Heredity
    f. 10 – DNA Structure and Replication
    g. 11 – DNA, Hot Pockets, & The Longest Word Ever
    h. 12 – Mitosis: Splitting Up is Complicated
    i. 15 – Speciation: Of Ligers & Men
    j. 17 – Evolutionary Development: Chicken Teeth
    k. 18 – Population Genetics: When Darwin Met Mendel
    l. 20 – Evolution: It's a Thing
    m. 33 – Great Glands: Your Endocrine System
2. CHEMISTRY (There are **46 courses** on this Playlist – all of which are essential. Below are the ones you should pay special concentration to)
    a. 4 – The Periodic Table
    b. 6 – Stoichiometry: Chemistry for Massive Creatures
    c. 7 – Water and Solutions – for Dirty Laundry
    d. 8 – Acid-Base Reactions in Solution
    e. 10 – Redox Reactions
    f. 17 – Energy & Chemistry
    g. 21 – Lab Techniques & Safety
    h. 22 – Atomic Hook-Ups – Types of Chemical Bonds
    i. 23 – Polar & Non-Polar Molecules
    j. 30 – pH and pOH
    k. 34 – Network Solids and Carbon
    l. 36 – Electrochemistry
    m. 40 – Hydrocarbon Power!
    n. 45 – Polymers
3. ANATOMY & PHYSIOLOGY
    a. All 40 episodes of Crash Course Psychology are essential to the curriculum.
4. PSYCHOLOGY
    a. All 40 episodes of Crash Course Psychology are essential to the curriculum.

YouTube Channels that aid in the study of Genetics

- **Ninja Nerd**
- **Neural Academy**
- **Khanacademymedicine**
- **Healthcare Triage**
- **Osmosis**
- **Alex Dainis**
- **Professor Dave Explains**
- **Nature video**
- **Kenhub**
- **Nile Red**
- **Khan Academy**
- **Brightstorm**
- **MinuteEarth**
- **AK Lectures**
- **Iken Edu**
- **Bozeman Science**
- **Biomedical and Biological Sciences**
- **iBiology**
- **Sajid Shaikh**
- **WEHImovies**
- **iBiology Techniques**
- **Amoeba Sisters**
- **Hussain Biology**
- **Animated Biology with arpan**
- **Henriks World**
- **MITK12Videos**
- **Shomu's Biology**
- **Medical Institution**
- **Joao's Lab**

Website Links

Phet Interactive Simulations – "Gene Expression – The Basics" Phet.colorado.edu/en/simulation/legacy/gene-expression-basics

- "Gene Machine: The Lac Operon" phet.colorado.edu/en/simulation/legacy/gene-machine-lac-operon
- "Molecular Motors" phet.colorado.edu/en/simulation/legacy/molecular-motors
- "Membrane Channels" phet.colorado.edu/en/simulation/legacy/membrane-channels
- "Stretching DNA" phet.colorado.edu/en/simulation/legacy/stretching-dna
- "pH Scale" phet.colorado.edu/en/simulation/ph-scale
- "Simplified MRI" phet.colorado.edu/en/simulation/legacy/mri

Molecular Workbench – Visual interactive simulations for teaching and learning science. mw.concord.org/modeler

Genetic Decoder – www.biocourseware.com/iphone/genecode/index_pad.htm

Apps

The following apps will aid in the study of genetics.

- **A Level Biology** (LearnersBox Education) https://play.google.com/store/apps/details?id=com.learnersbox.a.level.biology
- **Essential Anatomy** (3D4Medical) applications.3D4medical.com/essential_anatomy_3/
- **NEB Tools** (New England Biolabs Inc) https://itunes.apple.com/us/app/neb-tools/id350346827?mt=8&ign-mpt=uo%3D6
- **Genetics 4 Medics** (Apps4Medics Limited) https://play.google.com/store/apps/details?id=com.getetics4m&hl=en
- **Genetics Dictionary** (techuw) https://play.google.com/store/apps/details?id=com.genes.geneticsdictioryapp
- **Basic Molecular Biology** (Abdur Rahman Nirob) https://play.google.com/store/apps/details?id=com.onlineeducare.basicmolecularbiology&hl=en

OPEN CULTURE

Free online courses

www.openculture.com/freeonlinecourses

BIOLOGY Courses Section

1. Adolescent Health and Development (Robert Plum)
2. Animals in Research: Law, Policy, and Humane Sciences (Paul A. Locke & Alan M. Goldberg)
3. Biochemistry for Pre-Med (Kevin Ahern)
4. Biophotonics (UC Davis)
5. Bioscience in the 21st Century (Lehigh University)
6. Brain Structure and its Origin (Gerald Schneider)
7. Computational Molecular Biology (Douglas Brutlag)
8. Diet and Nutrition (LaTrobe University – Australia)
9. Enhancing Humane Science – Improving Animal Research (Alan M. Goldberg & James Owiny)
10. Evolution and Medicine (Stephen C. Stearns)
11. Evolution Ecology and Behavior (Stephen C. Stearns)
12. Exercise Science and Wellness (Arizona State)
13. Foundations of Computational and Systems Biology (Christopher Burge, David Gifford, Ernest Fraenkel)
14. Frontiers in Biomedical Engineering (W. Mark Saltzman)
15. General Biochemistry and Molecular Biology (UC Berkeley)
16. General Introduction to Plant Development, Form, and Function
17. Genetic Engineering in Medicine, Agriculture… (Robert B. Goldberg)
18. Genomes and Diversity (Mark Siegal)
19. Genomics and Computational Biology (George Church)
20. Genomic Medicine (Isaac Cohane)
21. Hacking Consciousness: Consciousness, Cognition, and the Brain (Michael Heinrich)
22. Health Behavior Change at Individual, Household, and Communal Levels (John Hopkins)
23. Human Behavioral Biology (Robert Sapolsky)
24. Introduction to Biochemistry (Kevin Ahern)
25. Introduction to Immunology (U-Maso Boston)
26. Introduction to Toxicology (UC Berkeley)
27. Issues in Mental Health Research in Developing Countries (Judith Bass)
28. Molecular Biology: Macromolecular Synthesis and Cellular Function (UC Berkeley)
29. Pharmacology (Sharon Burke)
30. Principles of Human Development (Jim Meyer)
31. Principles of Human Nutrition (Regina Belski) *Replaceable You: Stem Cell and Tissue Engineering (Jill Helms)
32. Straight Talk About Stem Cells (Christopher Scott)
33. The Brain: A User's Guide (Barry Jacobs)
34. Virology (Vincent Racaniello)

MATH Courses Section

1. A First Course in Linear Algebra (N. J. Wildberger)
2. Against All Odds: Inside Statistics (Pardis Sabeti)
3. Algebraic Topology: A Beginner's Course (N. J. Wildberger)
4. Analytic Geometry and Calculus (Benjamin Johnson)
5. Brief Calculus (Omayra Ortega)
6. Calculus (F. Michael Christ)
7. Calculus 1 (Matthew Leingang)
8. College Algebra (Patti Blanton)
9. Core Science Mathematics (SK Ray)
10. Differential Equations (Arthur Mattuck)
11. Differential and Integral Calculus (Steve Butler)
12. Empirical Research Methods (Carnegie Mellon)
13. Introduction to Probability and Statistics (Fletcher Ibser)
14. Mathematics for Computer Science (Tom Leighton)*
15. Rational Trigonometry (N. J. Wildberger)
16. Trigonometry (Jason Rosenberry)

ENGINEERING Courses Section

1. Chemical Engineering: Process Dynamics and Controls (Peter Woolf)
2. Elementary Fluid Mechanics (Mark Stacey)
3. Fluid Mechanics (T.I. Eldho)
4. Introduction to Chemical Engineering (Channing Robertson)
5. Introduction to Microelectric Circuits (Chang-Hasnain)
6. Microelectric Devices and Circuits (Sayeef Salahuddin)
7. Nano-to-Macro Transport Processes (Gang Chen)
8. Nanomanufacturing (John Hart)
9. Nonlinear Finite Element Analysis (Klaus-Jurgen Bathe)
10. Understanding Lasers and Fiberoptics (Shaoul Ezekiel)

PSYCHOLOGY & NEUROSCIENCE Courses Section

1. Behavioral Neuroscience Laboratory (Christof Koch & R. Clay Reid)
2. Environmental Psychology (Daniel Stokols)
3. Neural Networks and Biological Modeling (Wolfram Gerstner)

CHEMISTRY Courses Section

1. Biochemistry 1 (S. Dasgupta)
2. Chemical Structure and Reactivity (Peter Vollhardt)
3. Chemistry (Chemical Stoichiometry) (Carnegie Mellon)
4. Freshman Organic Chemistry (Stephen L. Craig)
5. Freshman Organic Chemistry II (J. Michael McBride)
6. Life, Universe & Everything: Chemistry of Our Daily Lives (Sean Hickey)
7. Introduction to Quantum Chemistry (KL Sebastian)
8. Organic Chemistry (James Nowick)
9. Organic Chemistry 1 (Sean Hickey)
10. Organic Chemistry 2 (Sean Hickey)
11. Organic Reactions and Pharmaceuticals (Steven Hardinger)
12. Organic Spectroscopy (James Nowick)
13. Principles of Chemical Science (Catherine Drennan and Elizabeth Vogel Taylor)

TEXTBOOKS

(All currently **available at www.amazon.com**)

Text Material – According to your budget, preview everything you can about each book, and pick which ones you're most interested in first.

1. Netter's Essential Biochemistry (Peter Ronner)
2. Genetics: Analysis & Principles 5th Edition (Robert J. Brooker)
3. Fundamental Microbiology: Body Systems Edition 3rd Edition (Jeffrey C. Pommerville)
4. Genetics: A Conceptual Approach, 5th Addition (Benjamin A. Pierce)
5. DNA Science (David A. Micklos & Greg A. Freyer)
6. The Epigenetics Revolution: How Modern Biology Is Rewriting Our Understanding of Genetics, Disease, and Inheritance (Nessa Carey)
7. Chemistry: A Molecular Approach (Nivaldo J. Tro)
8. Chemical Principles 7th Edition (Steven S. Zumdahl, Donald J. DeCoste)
9. The Complete Human Body (Alice Roberts/DK Publishing)
10. Trachtenberg Speed System of Basic Mathematics (Jakow Trachtenberg)
11. Molecular Biology of the Cell (Bruce Alberts)
12. Molecular Biology of the Cell 6E – The Problems Book (John Wilson)
13. Janeway's Immunobiology (Kenneth Murphy)
14. Organic Chemistry 2nd Edition (David R. Klein)
15. Laboratory Techniques in Organic Chemistry (Jerry R. Mohrig)
16. Quantitative Chemical Analysis (Daniel C. Harris)
17. Guyton and Hall Textbook of Medical Physiology, 13e (Guyton Physiology) – (John E. Hail)
18. Genetic Entropy (John C. Sanford)
19. Wheater's Functional Histology (Barbara Young)
20. Cunningham's Textbook of Veterinary Physiology, 5e (Bradley G. Klein)
21. Morgan and Mikhail's Clinical Anesthesiology 5th Edition (John Butterworth)
22. The Extended Phenotype: The Long Reach of the Gene (Richard Dawkins)

PODCASTS

Neuroscience Podcasts are compensatory of classroom discussion. They'll allow you to be immersed in social conversation of the material contrary to the lecture form of many of the above media.

1. Genetics in Medicine: Official Journal of the American College of Medical Genetics and Genomics
2. Naked Genetics Podcast

T.L.U.V.I. POSTERS

All posters available at **www.theupwardeducation.com/tluviposters**

1. T.L.U.V.I. Poster #2: Potential Excitement
2. T.L.U.V.I. Poster #5: Genetics #1: You-Carry-All-This
3. T.L.U.V.I. Poster #6: Chemistry #1

NOTES & PERSONAL ADDITIONS TO CURRICULUM

Experiential Learning

Potential Careers, Condensed Wisdom, and Creative Compensations

Pink = **Medically-based** Blue = **Technology-based** Green = **Research-based**

Potential Careers in the field of Genetics

Many of these span two or three of the colored categories above. The color correlation used is the more defining form of the vocation.

Agricultural/Plant Scientist
Animal Science
Entomology
Forensics
Medical Genetics
Microbiology – microbial genetics

Statistical Genetics
Veterinary Medicine
Wildlife Biology
Cytogeneticists
Molecular Genetic Technologist
Genetic Counselor

Bioinformatics
Forensic DNA Analyst
Genetics Research Technician
Botanist

Brief Career Descriptions

Research Geneticist

Agricultural Biotechnology: Area of agricultural science involving the use of tools and techniques including genetic engineering, molecular markers, molecular diagnostics, vaccines, and tissues culture, to modify living organisms (plants, animals, and microorganisms).
Agricultural Scientist: the multidisciplinary field of biology that encompasses the variety of studies that are used in the practice and understanding of agriculture.
Animal Science: Branch of zoology concerning the overall biological and mechanistic behavior of animals.
Botanist: Botany is a branch of biology concerning the science and study of plant life.
Entomology: A branch of zoology that concerns the scientific study of insects.
Forensics: Forensic science is any scientific field that is applied to the field of law. Forensic scientists collect, preserve, and analyze scientific evidence during the course of an investigation.
Microbiology – microbial genetics: The study of microscopic organisms – encompassing numerous sub-disciplines including virology, mycology, parasitology, etc.
Statistical Genetics: Scientific field concerned with the development and application of statistical methods for drawing inferences from genetic data.
Veterinary Medicine: Branch of medicine that deals with the prevention, diagnosis and treatment of disease, disorder and injury in animals.
Wildlife Biology: Studies and/or manages wild animals and their habitats.
Bioinformatics: Interdisciplinary study of biology that uses computer sciences and statistics to analyze and interpret biological data.

Clinical Geneticist

Cytogeneticists: Branch of genetics that is concerned with the study of the structure and function of the cell, especially the chromosomes.
Medical Genetics: The specialty of medicine involving the diagnosis, management, and counseling of hereditary disorders.
Molecular Genetic Technologist: Involves the conceptualization, troubleshooting, and/or modification to molecular based technologies.
Genetic Counselor: Provides information to individuals or families who have or who are at risk of developing genetic disorders.
Forensic DNA Analyst: Branch of forensic science specifically dealing with the analysis of DNA evidence.
Genetics Research Technician: Concerns the analysis of technical data from genetics-based machinery.

Experiential Self-Education in Genetics

A University Degree is a certificate verifying your aptitude in a particular field. Completing 100% of the Geneticist's Curriculum (with a Superficial, Conceptual, and Technical comprehension of the material) will merit you a Master's Degree equivalent in the field of Genetics knowledge. Because your education is unconventional, it is up to you to discover a creative way of exhibiting your mastery of the field to future employers. This curriculum provides a means of aptitude, not a guaranteed opportunity.

This section of the curriculum gets as close as possible to providing condensed wisdom traditionally only attained through experience in professional or institutional settings (universities, labs, sites, etc.). Mastering all the details and particularities of the information below (bolstered by your knowledge from above) will produce the technical skill necessary to (somewhat) seamlessly transition into most of the careers listed above without much orientation needed.

Terminology

As you're going to come across all of these concepts many times, the definitions given here are brief summations in everyday language. It would be useful to familiarize yourself with these concepts at the very start of your studies – it will considerably expedite your understanding of the field.

The 4 essential types of biomolecules necessary to support life are: **nucleic acids, amino acids, lipids, and carbohydrates. These are the four fabrics of life.**
Nucleic Acids: combine in organized clusters and systems to form genes. [DNA and RNA]
Amino Acids: combine to form proteins. [POLYPEPTIDES and PRIONS]
Lipids: combine to form fats [PHOSPHOLIPIDS]
Carbohydrates: are sugar molecules and systematize as saccharides. [GLUCOSE]

- Carbon is a diversely bonding chemical element. Most biomolecules possess a spine of carbon.
- Individual molecular building blocks of each biomolecule are called monomers. Several monomers bonded in a row are a polymer. The building of a chain of several monomers is called polymerization. The ultimate result of a gene is the polymerization of an amino acid. The ultimate result of a polymerized amino acid is a protein that can have any number of effects on a cell (or any number of cells). Genes code for protein construction. Constructed proteins makes an effect.

Quick Terminology Summary of the basics of Genetics

Nucleobases: Letters in the genetic lexicon.
Nucleotides: Syllables that can be mixed and matched to form different words (codons).
Codons: Words – consisting of 3 nucleotides – in the DNA/RNA dialect. The nucleotides of a codon are always consecutive (immediately next to each other).
Genes: A sentence, multiple sentences, or paragraph made out of codons. Genes contain the information of the product to be printed.
Promoter: Chapter Title (Gene Title). A promoter is what cues the appropriate transcription factors to get to work on preparing for transcription.
Introns: Gene-specific nonsense punctuation (unnecessary for translation) that is edited out before mRNA leaves the nucleus.
Exons: The non-intron part of the gene that is used in translation; the complete (operative) copy of the gene itself.
RNAP (RNA-polymerase): DNA copying machine & RNA printing machine. RNAP slides down a DNA sequence printing an RNA copy of the gene its currently on.
Transcription Factors (TFs): Helper enzymes and molecules that assist in the dynamics of DNA transcription.
Transcription: the copying of DNA into a RNA copy of the gene; or, the copying of RNA into cDNA via Reverse Transcription.
mRNA: A copy of a gene (that is edited into a workable copy by splicesomes) that is used as polypeptide-printing instructions.
Spliceosome: mRNA editor protein machinery found inside the nucleus.
RanGTP: protein that taxis mRNA from the nucleus to the cytoplasm.
Translation: The process of a ribosome reading an mRNA and printing a polypeptide. A polypeptide is an early-stage protein (or protein-complex part).
tRNA: A middle-man in the process of translation. The actual translator of mRNA in that it binds the codon's corresponding amino acid on its other side.
Chromosomes: Volumes of an organism's genetic library; ranging from as few as 450 genes (on the Y chromosome), to as many as 4200+ genes (on chromosome 1)
Chromatin: Different varieties of an unraveled state of a chromosome when relaxed in the nucleus of the cell. Full chromosome condensation is a mitosis exclusive.
Mitosis: Cell division. When a cell clones itself by first replicating its organelles, then DNA, then its nucleus, then its body. Each cell has its own copy of the DNA.
Nucleosome: a spool in which DNA wraps around when inactive in a heterochromatin state. Consists of 8 histone proteins (that bind to DNA).
Genotype: The genetic identity of a gene. A genotype is the existence of a gene in the form of its DNA composition.
Phenotype: The physical identity of a gene (it's expression in proteins). A phenotype is the actual form and function of an activated gene.
Heterochromatin: Packed up coils of inactive DNA.
Euchromatin: Unpacked DNA – exposed to the environment of the nucleoplasm – awaiting activation, or currently active.
Chemical Formula: In all sciences, a chemical formula is a shorthand summary of the name and number of atoms in a substance. The capital letter is the symbol for the atom; the subscript number (to the right of the letter) is how much of each chemical element is in the substance. [Example: $C_6H_{12}O_6$]

Concepts

Genes

Genes are the concretized potential of a biological result. **Essentially, the genome is a switchboard, with genes being the switches. When a gene is "expressed", the switch is in the "on" position. When a gene is inactive, repressed, or restricted, it is in an "off" position. Genes are codes for printing proteins.** Once an mRNA copy of the gene is printed into a Primary Structure protein. The protein goes through several changes before appearing in its final "ready to work" phase. The final form of a protein could be a molecule that causes a chain reaction of cellular activity. **By controlling the production of the final protein product, the gene partly controls the chain reaction of cellular activity that results from it.**

Your genome is all of your individual switches in all of your chromosomes.
Active genes are those who's DNA is exposed to the nucleoplasm and available for copying.
Inactive genes are those that are rolled up into heterochromatin: a conceptual "filing cabinet" structure that keeps inactive genes tidily tucked away so as not to take up extra space.

Genome

The genome is the library of an organism's physical life. The instruction for the growth, development, and sustenance of your body's physical (and mental) existences is contained within each individual's genome.

Nitrogenous Bases:

Nucleobases are letters in the book of genome. Nitrogenous bases are nucleic acids that combine (in a process known as polymerization) to form the DNA double helix. Nitrogenous bases are the simplest core components of the genetic code in the same way letters are in a book, or cells are in a body.
The Nitrogenous Bases that make up the alphabet of all of genetics are:
Adenine (A): [Purine] [$C_5H_5N_5$]
Guanine (G): [Purine] [$C_5N_5H_5O$]
Uracil (U): [$C_4N_2H_4O_2$][replaces Thymine in RNA only]
Thymine (T): [Pyrimidine] [$C_5H_6N_2O_2$]
Cytosine (C): [Pyrimidine] [$C_4N_5H_3O$]

Nucleotides

Nucleobases are the individual molecules of a nucleotide that bind in the center of the helix.
Nucleosides are nucleobases attached to either ribose or deoxyribose, but not any phosphate groups. Nucleosides can be built up to –tides or down to –bases.
Nucleotides are nucleosides attached to one or more phosphate groups. **Nucleotides are the building blocks of DNA and RNA.** The polymerization of these monomers in a double helix formation forms DNA (deoxyribonucleic acid). The nucleobase from one nucleotide reaches across to the complementary base on the opposite strand and forms a Hydrogen Bond. A string of nucleotides on each strand doing this creates a DNA molecule (the nucleobases being at the center of the double helix).

Complementary Base Pairing

An essential rule to the language of genetics is Complementary Base Pairing. What is it? Adenine (A) always pairs with Thymine (T) – or (Uracil, in RNA); and Guanine (G) always pairs with Cytosine (C). "A" pairs with "T" (or "U"), "G" pairs with "C". That's complementary base pairing. The unit "bp" stands for "**Base Pairs**" and is often used when referring to length measurements of genetic sequences.

The DNA double helix is formed by an A from one strand binding with a T from the other strand; and a G from one strand binding with a C from the other strand. DNA and RNA are so easily manipulated in laboratory settings because knowing one side of a strand means you automatically know the other. All DNA-copying enzymes have to do to perform their function is match A's with T's (and vice versa), and G's with C's (and vice versa). The variety in genes comes from the variety and length in sequences. Faulty base pairings (that go uncorrected) result in mutations.

You'll find all throughout your biological studies that many atoms and molecules have behavior that is entirely dictated by the nature of their surroundings. **Polar molecules are those that have opposite electric charges on each of their ends (one side being positive, while the other is negative).** Opposite electric charges attract, and identical electric charges repel each other. This is not a trait of biomolecules only, but of electromagnetism itself (one of the three fabrics of the universe). If you're ever wondering how all this chemistry got started in the first place – keep in mind that self-organization is an inherent part of nature in many ways.

DNA (Deoxyribonucleic Acid)

DNA is the lexicon of all physical life. Its various combinations carry the code for all of the (structural and functional) cellular and system potentials of an organism. DNA is the first order in the existence of any life; it is the information molecule containing all of its potential structural actions. DNA is not the life itself; the ordered expression of genes into a self-renewing entity is what defines life.

- **cDNA (Complementary DNA)**
  - cDNA is a genetic sequence that has been copied from RNA via Reverse Transcriptase (an enzyme that can copy RNA). cDNA consists of exons with no introns, and is used as the working copy when we want a prokaryote to mass produce a human gene. The human gene – in cDNA form – is given to the prokaryotes, which mass-produce the gene. Since prokaryotes don't have introns, cDNA is needed for cloning.

RNA (Ribonucleic Acid)

RNA is one half of a DNA sequence (one jagged tooth out of the two in the double helix). It serves as a direct copy to genetic sequences, as well as binding spots for DNA-binding domains (such as those found in ribosomes). Ribosomes are the machines that translate the RNA genetic information into a physical polypeptide. Aside from the single strand, RNA is different than DNA in that its backbone is composed of ribonucleic acid (instead of deoxyribonucleic).

- **mRNA (Messenger RNA)**
  - When a gene is activated (by transcription factors binding to a promoter) and copied by RNApolymerase, the copy of the gene is known as mRNA. It is called "messenger" RNA because the copy is used to convey the message of the original gene. Like a message, mRNA is duly escorted out of the nucleus and into the cytoplasm. Where it is delivered to the lower half of a waiting ribosome. Landing on the ribosome cues a tRNA to come bind with the mRNA – which cues the top half of the ribosome to come complete the ribosome…which cues the process of translation.
- **miRNA (MicroRNA)**
  - miRNA is RNA that is not used as a messenger for polypeptide printing, Instead, It serves as a regulatory factor for gene expression, and as structural material for ribosomes (built in the nucleolus) and other structures involving RNA as a structural component. Ribosomes are partly built of RNA; RNA had to get in there somehow. In the nucleolus you'll find miRNA being embedded in the proteins of the small and large subunits of ribosomes (as they're being created). miRNA can serve functions such as plopping on top of genes (or parts of genes) to silence them and/or restrict activation.
- **tRNA (TransferRNA)**
  - The bottom of a tRNA molecule consists of an anti-codon. An anti-codon binds to an mRNA codon at the bottom of a ribosome. The top of a tRNA molecule binds to an amino acid monomer. In the cytoplasm of the cell, a tRNA binds to an amino acid, then it finds an active ribosome to deliver the amino acid to (relative to the active codon). tRNA is the one pronouncing every word (codon) of the gene out loud, into reality (amino acid), into a cohesive rough speech (final polypeptide).
    - Post-translational modifications cut the speech into its final draft.
- **sRNAs (small RNA)**
  - Various types of RNA exist, such as: snoRNA (small nucleolar), siRNA (small interfering), snRNA (small nuclear). They serve various functions such as transcription aid and serving as the core unit RNA silencing,

Introns & Exons

With so many of the same types of molecules roaming about and waiting to activate anything and everything that'll let them, it is necessary for all cellular processes to have several levels of controlling the final action of their ultimate purpose. Another such control over gene expression (aside from heterochromatin packing, specific unpacking factors, and unique promoters) are introns**. Introns are sequences of DNA found all throughout a gene's sequence that do not play a role in coding for the final polypeptide product. Introns can be seen as "unwanted" footage that's edited out (by splicesomes) before a release. Exons are the operative base pairs in the translation process.** Splicesomes are protein machines inside the nucleus that clip out introns and chronologically cohere exons. Introns are recycled for their nucleotides. Introns are "filler" base-pairs that occupy the parts of a DNA helix not taken up by exons.

Alleles

An allele is a variety in any given gene. A single allele is a single variety on any given trait. Alleles often combine to mix and match in the formation of a single phenotypic expression; or, have different DNA sequences, but code for identically functioning proteins (different genotypes, similar phenotype).
Dominant / Recessive: Dominant Alleles determine the phenotype when present. Recessive Alleles determine the phenotype when no dominant alleles are present. When both are present, the recessive allele may pass on to the next generation, but recessive alleles are not active until paired with another recessive allele (or the host experiences something that knocks out the dominant allele – leaving only the recessive left).
Homozygous / Heterozygous: A person with two dominant or recessive alleles has only one allele variant (one – of the same type of allele – on each chromosome); such a person is homozygous for either a dominant or recessive trait. Homozygous is having two of the same alleles (2 dominant, or 2 recessive). Heterozygous is having one of each (1 Dominant and 1 Recessive). A heterozygous person has two allele variants. Even though alleles can affect the form and function of a trait, mutations in allele genotypes do not always produce visible phenotypes. Sometimes recessive alleles can be active simultaneously with dominant ones – with the phenotypes either producing a new a mixing effect, or a new type of appearance (symmetrical or asymmetrical).

Mutations

Mutations are non-traditional changes in the genetic code – for example, the replacing of one nucleotide for another. Mutations may or may not express themselves phenotypically. Mutations can be advantageous, detrimental, or inconsequential. Mutations are permanent changes in genes. If the error is corrected, and not expressed, it does not qualify as a mutation.

Mitosis

Mitosis is the act of cell replication. Cells clone themselves as appropriate to support the life of the organism. Mitosis is the cloning process. Mitosis takes place in several stages, the end result being two separate cells (where there used to be one) – each with its own copy of the original DNA. The phases of mitosis are:
Interphase is the normal, daily, phase. When mitosis is oncoming, the centrosomes (microtubule factories) duplicate.
Prophase: Chromosomes duplicate, organelles duplicate, and each centrosome (of the 2) moves to an opposite side of the cell while making spindles.
Metaphase: Chromatin becomes twin chromosomes. Twin chromosomes meet in the center of the nucleus and attaches to surrounding kinetochore spindles.
Anaphase: Spindles from each centrosome pull the twin chromosomes apart at the center toward each opposite side.
Telophase: With the duplication and division of the nucleus, the rest of the cell divides in half until there are two separate cells where there was previously one.

Epigenetics

- Mutations are changes in the nucleotide system of DNA that may or may not affect phenotypic expression. Epigenetic changes are alterations to the DNA molecule – but not the genetic sequence – that affect phenotypic expression. **Epigenetic changes modify the activation of certain genes, but not the genetic code sequence of DNA.** Epigenetics is the study of mitotically and/or meiotically heritable changes in gene function that cannot be explained by changes in DNA sequence. **There are several different types of epigenetic processes, all of which have the ultimate effect of either silencing or activating the expression of a gene(s). DNA methylation, nucleosome/histone modification, promoter silencing, and prions are common types of epigenetic changes.**
- Lifestyle and environmental factors that cause and effect transcriptional variation in phenotypic expression: Diet, sedentary lifestyle, sleep deprivation, prions, heavy drug use, DNA damage, sustained mental stress, untreated physical trauma.

Transcription Factors (TF)

- There are several levels of control for appropriately moderating gene expression, but Transcription Factors are the primary controls for gene expression. **Transcription Factors are any proteins that have a role in the transcription process.** There are thousands of transcription factors that are used in the control of genetic expression. Transcription factors prepare DNA for transcription, attach to the promoter and serve as a rallying point for other transcription factors, stabilize the DNA molecule while active, block/repress genes when needed, chemically unlock heterochromatin – loosening up DNA (to be available for transcription), lock DNA to histones (restricting the expression of the gene(s), aid in the copying of DNA (and RNA), and generally do everything possible to make sure that the key events surrounding transcription go as planned.

Enzymes

- **Enzymes are catalysts of cellular chemical activities (and chain reactions).** They are essential in pretty much every cellular process of considerable (and minimal) importance. There are thousands of enzymes per cell; here is a list of every single one of them……just kidding. Here is a list of some of the all-star enzymes in the realm of genetics (and their general purpose):
  - **DNA Polymerase (DNAP):** Copies DNA from DNA
  - **RNA Polymerase (RNAP):** Copies RNA from DNA (euchromatin)
  - **Helicase:** Unzips the DNA double helix for DNAP.
  - **Ligase:** Zips the DNA double helix back up after a replication (or transcription) enzyme has done its work.
  - **Primase:** deposits a sort of runway sequence for DNAP to land on.
  - **Histone Acetyltransferase (HAT):** weakens the connection of DNA to histones (allowing for transcription).
  - **Histone Deacetylase (HDAC):** strengthens the connection of DNA to histones (restricting transcription).
  - **Reverse Transcriptase (RT):** Copies a cDNA strand from an RNA template.

Viruses

- If you consider a virus a living thing: viruses are by far the most abundant living thing on the entire planet. Bacteria outnumber humans millions to one, and viruses considerably outnumber bacteria – though the ratio of just how much so can never be quite certain. Viruses are so simple that their only functions are basically "invasion" and "replication"
  - Viruses need a host to thrive and reproduce. Humans, bacteria, fungi, and pretty much any living thing bigger than a virus (which is every living thing) can be considered a potential host. **Viruses hijack genetic sequencing and input their own code into the cell. The virus's genetic code makes its way to the nucleus, and either tricks or forces the host's molecular machinery to replicate its genetic material.**
  - Viruses can spread via ingestion, surface permeability, inhalation/respiration, body fluids, and any other outlet of entry that a body (human or otherwise) has available.
- Retroviruses are viruses that – after invading a host cell – use their own reverse transcriptase enzyme to produce DNA from its own RNA contents. The viral DNA is then assimilated into the host cell's genome, and the host cell's machinery (unwillingly) treats it like a member of the family, transcribing and translating it just like it would any other active gene.
  - Transcribing multiplies the genes of the virus, translation ends up producing more of the proteins needed for the new viruses.
- It is an absolute certainty that your studies in genetics will bring you somewhere into the realm of virology – whether at the deep or shallow end of the subject depends on your particular field. Viruses are fascinating studies of genetic potential (and transfer), and can lead to even more discoveries for medical treatments than they already have. Vaccination is the utilization of a protective technique (against viruses) that your body does on its own.

Technology

DNA Microarray

- A Microarray – in general – is a multiplex laboratory procedure that uses a computer to place up to thousands of specimens on a single chip, place thousands of chips on a single plate, and studies the qualitative and quantitative measures of said specimen(s) features of interest.
- A DNA Microarray is a slide with rows of wells (known as "features") that are used as a chamber for mass storage of mRNA or cDNA probes.
- **mRNA / cDNA Probes**
  - **Are single strands of a gene that are used in experiments to sort of "fish" for a particular gene in the subject being studied.** If you want to find out if Gene X is in Cell A, you would first find an organism sporting active mRNA for Gene X. After extracting a copy of Gene X from the host organism, you'd then use that (or a cDNA copy) as a probe in a microarray by placing hundreds of that Gene X copy per feature.
- In a separate event, the target cell(s) have had the target gene isolated and stained so as to appear fluorescent. The stained target genes are then introduced into each of the mRNA wells on the slide, and the probes in the microarray will "catch" the complementary stained sequences.
  - Computers are used to analyze the data and provide visuals of the stains, as well as condense the information into manageability.

Polymerase Chain Reaction (PCR)

- Because all living things share the same lexicon, our genes are interchangeable. PCR is essentially a gene mass-manufacturing technique where a gene is taken from one organism and put into a solution of enzymes to copy continuously (and exponentially).
- In a typical PCR, a heat-resistant, admirably uppity, DNA polymerase (DNAP) is administered to a solution of freelance nucleotides – and the DNA strands intended for copying. DNAP copies the original targets, and copies the copies it creates. PCR is arguably the greatest tool geneticists have at their disposal – it more often than not has a role in every other aspect of DNA analysis technology. **PCR is a DNA multiplying technique.**

X-Ray Crystallography

- Biomolecules are usually too small to interact directly with visible light (which means they can't be seen with a traditional microscope). X-ray crystallography is the process of creating a crystalline structure composed entirely of identical molecules, sending x-ray beams directly through the crystal, capturing the deflected x-ray data, and extrapolating the shape of an unknown molecule from the data received from the deflections.
- The biomolecules must be crystallized because the readings from the diffracted rays would be unreadable otherwise.
  - If you just plopped a bunch of one type of molecule into a tube (or any other container), they will be stacked in an unorganized fashion. This disorganization would make it impossible to conclude the actual structure of the molecule you're studying because you don't know its orientation. "What way was it facing when it deflected like-so?" "Is that from the top or bottom of the molecule?" Etc.
  - In crystalline formation, the molecules are organized in a way that ensures the orientation of the molecule. The more pure the crystal is, the easier it is to discern results. Also, in crystal form the studied substance does not need a container (being a solid).
- Whenever you see detailed cellular maps of any type of biomolecule, there's a large chance that x-ray crystallography has something to do with that visualization.

Skills

Animal Handling

- The vast amount of genetics research can have you working with animals (and prokaryotes) much more often than you find yourself working with humans (and human DNA). As you'll learn through the knowledge section of the curriculum – this is for both safety and convenience reasons.
- When testing out new medical solutions, animal testing is a safer approach then experimenting on humans.
  - If you disagree with animal testing, then an equal alternative needs to be suggested (and would be welcomed by everyone).
- The best thing possible for any experiment is to have multiple subjects (of similar or identical genetic identities). For this reason, the fruit fly (drosophila) is known as the model organism for genetic tests (due to its more or less unlimited access, numbers, and genes identified).
- Look for places that give you experience in the handling of animals. Seek employment at – or establish credit with – agencies/companies/stores/etc. whose employees and/or customers have the opportunity to handle animals regularly. Learning to humanely view them will allow for more humane considerations in their testing.
- Environmental factors can trigger epigenetic changes to gene expression. Tests from "survivable" living conditions may yield different results from tests from "ideal" conditions.

Zoological Knowledge

- While most life on Earth shares genome similarities, it's quite obvious that a few genotypic differences can segregate a being into an entirely different taxonomic rank. As a geneticist, it will be important for you to understand the operating factors involved in prokaryotic genetics as well as whatever field of study (human, animal, plant) you wish to go into. **Prokaryotes are absolutely essential in the applied sciences of genetics.** Their bodies – and/or the special cellular contents of their bodies – are used for the mass-producing, mass-copying, and mass-splicing of genetic sequences when practicing recombinant techniques.
- It is highly likely that at some point in the future we (humans) will discover a way to completely regrow amputated limbs. There is no technical, nor scientific barriers (theoretical or otherwise) that prevent us from doing this – the only current barrier is "we don't know how to, yet".
  - Do you know how we figure something like this out? Studying animals that can regrow limbs, identifying the genes and gene activation features that regulate this feature, and meticulously mixing and matching the appropriate factors and gene sequences necessary to transfer this ability (via recombinant DNA techniques) from one organism to another. There is already overwhelming proof (and practice) that genes can be transferred from one being to another and expressed in the recipient; but you need to know just as much about the donor as you do the recipient. Even if it took centuries to figure out: would it not be worth it?
- For this, and innumerable other reasons, it will be highly worth your while to invest a bit of brainpower in comparative genomics and physiology.

DNA Modeling

- One of the best ways to memorize anything is to interact with it on as many levels as possible. If you get in the habit of not only drawing DNA (and essential molecules in DNA dynamics and expression), but building physical models as well, you will eventually possess a technically accurate memory of the most crucial chemical formulas and structures underlying the subject of genetics.
  - There are plenty of chemistry sets available (to order online) that provide kits for making ball and stick models out of atoms. *It should probably be noted that ball-and-stick modeling played a large part in finalizing the structure of DNA for the first time.
    - *DNA is a big molecule. If modeling sets are outside your budget, drawing is more than good enough. Creating a strand of DNA (even a small one) will likely require multiple modeling sets.
  - A physical/tangible understanding of the molecular structures surrounding genetics will lead to an intuitive understanding of its mechanics.

The Geneticist Curriculum is designed to be an as-available approach to the pursuit of knowledge and/or employable aptitude in ALL of the various fields of genetics: a "Universal Geneticist". This curriculum is accessible to those under 10years of age and those over 100years of age – and everyone in between. The sole gauge of your success with the curriculum is your interest in the field, and the required tenacity necessary to complete a total education (in any field).

Your completion of this curriculum will not guarantee you employment, but it will make you capable of employment in each neuroscience field(s) of your interest. If nobody will hire you, or nobody is working on what you're interested in: pioneer your own program.

For potential assistance in pioneering your own programs, or vocation, see: "Entrepreneur's Curriculum"

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