# Organic Molecules
Functional Groups

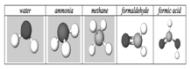
Amines: Weak Organic Bases
*Carbon Derivatives of Ammonia*

Dr. Ron Rusay

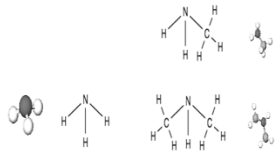


## Small Organic Molecules
*Common Functional Groups*

| Name | General Formula |
|---|---|
| Alcohols | R–OH |
| Ethers | R–O–R′ |
| Amines | R–$NH_2$ |
| Carboxylic Acids |  |

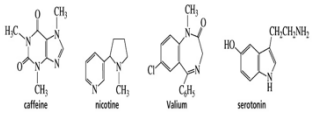


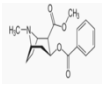

## Small Organic Molecules
*Ammonia & Amines*



Household ammonia (aqueous)

## *Alkaloids: Naturally Occuring Bases*
*Nitrogen Heterocycles*



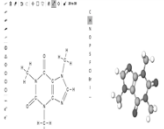


cocaine


ibogaine

https://www.youtube.com/watch?v=OTVE5iPMKLg

Coffee: The Greatest Addiction Ever
*( A testimonial?)*

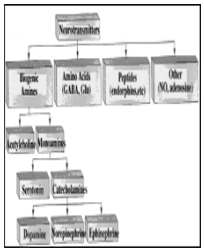

https://www.youtube.com/watch?v=YuJOhpNS0IY

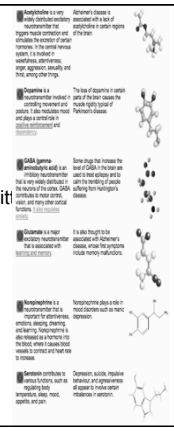
http://www.coca-cola.co.uk/stories/caffeine-counter

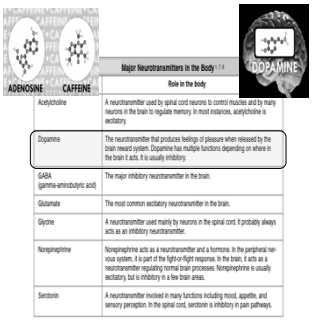
**Caffeine: a natural insecticide, $LD_{50}$ = 150 mg/kg**

Amines & Neurotransmitters

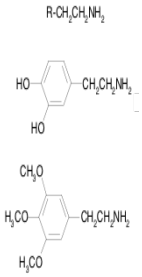



Neurotransmitt



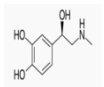



http://learn.genetics.utah.edu/content/addiction/reward/pathways.html

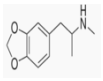


*phenyl*
-ethylamine
dopamine
mescaline

*F.D.A. Agrees to New Trials for Ecstasy as Relief for PTSD Patients (Nov. 2016)*

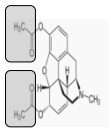


Epinephrine (adrenaline)



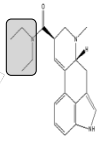
Ecstacy (mdma)

morphine

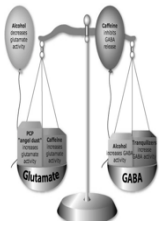


heroin

Lysergic acid



LSD



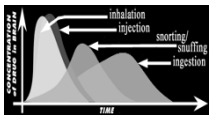

A Delicate Balance

*Drug Uptake:*
Rank from slowest to fastest.
a) injection; b) ingestion; c) inhalation; d) snorti


A) a<b<c<d B) c<a<d<b

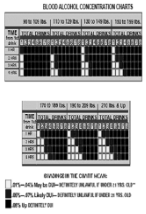
C) b<d<a<c D) d<b<c<a

*Drug Uptake:*
Rank from slowest to fastest.
a) injection; b) ingestion; c) inhalation; d) snorti

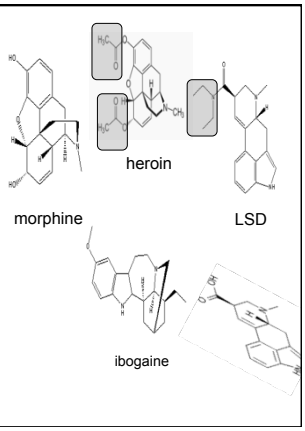



A) a<b<c<d B) c<a<d<b

**C) b<d<a<c** D) d<b<c<a



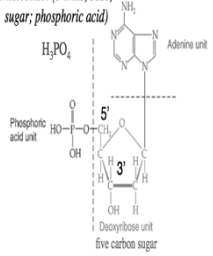
http://www%2Dnci.rutgers.edu/%7Elwh/drugs/
http://web.indstate.edu/thcme/mwking/nerves.html#table
http://www.sfn.org/briefings/addiction.html
http://faculty.washington.edu/chudler/amp.html




## *Nucleic "Acids"*

*Nucleotide: (3 units, base; sugar; phosphoric acid)*

*Organic base:* R-$NH_2$




*Nucleoside: does not include the phosphoric acid*

## *Genetic Bases in DNA & RNA*

- DNA and RNA have different sugars (dexoyribose vs. ribose).
- There are only five bases found in DNA and RNA:
  - adenine (A),
  - guanine (G),
  - cytosine (C),
  - thymine (T found in DNA only), and
  - uracil (U found in RNA only).

## *DNA & RNA: Nucleic Acids*

- Store & carry genetic information.

- DNA (de ic acids) have molecul ~ $6 \times 10^6$ to $16 \times 10^6$ daltons (amu) and are found inside the nucleus of the cell.
- RNA (ribonucleic acids) have molecular weights ~ 20,000 to 40,000 amu and are found in the cytoplasm outside the nucleus of the cell.

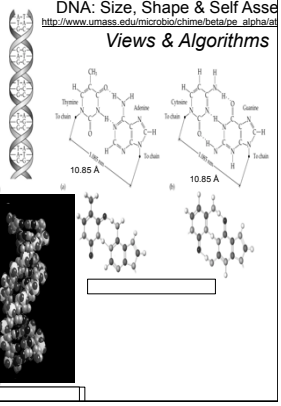
## *Genetics & DNA*

♀ **XX** ♂ **XY**


## DNA: Size, Shape & Self Asse

http://www.umass.edu/microbio/chime/beta/pe_alpha/at

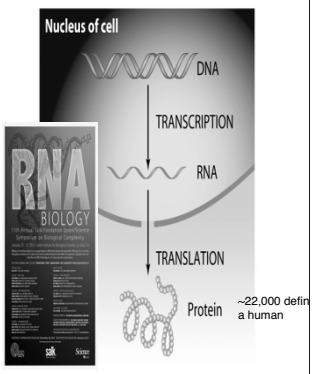
*Views & Algorithms*




## *Protein Biosynthesis*


http://chemconnections.org/general/movies/PROTEIN1.MOV

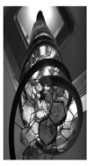
https://www.dnalc.org/resources/3d/09-how-much-dna-codes-for-protein.html




~22,000 defin a human

## Central Dogma

DNA → (Transcription) → mRNA → (Translation) → Protein



Amanda Ruby

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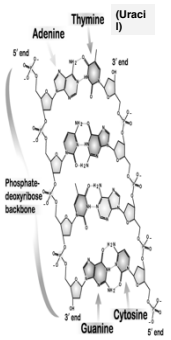
## mRNA

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## mRNA

### Sense vs. Antisense strands

- **Sense strand** - the "other" strand, not transcribed.
- **Antisense strand** - the one mRNA attaches to, and is complimentary to.
- mRNA is similar to the sense strand, except T→U.


Antisense DNA from the left: GTAG
mRNA: CAUC

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## mRNA

| | | |
|---|---|---|
| DNA | Coding Strand (Codons) | 5'>>>·····TTC·····>>>3' |
| | Template Strand (Anti-codons) | 3'<<<·····AAG·····<<<5' |
| mRNA | Message (Codons) | 5'>>>·····UUC·····>>>3' |
| tRNA | Transfer (Anti-codons) | 3'<<<AAG<<<5' |
| Protein | Amino Acid | Amino>>>Phenylalanine>>>Carboxy |

Coding Strand = Antisense strand:
TTC
Anti-coding = Sense strand
mRNA:
UUC

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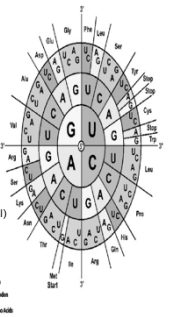
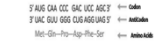
## *Protein Biosynthesis*

### Codons

- mRNA is translated in "chunks" of three, called **codons**
- The starting nucleotide is determined using bioinformatics to find the **reading frame**
- The genetic code is **degenerate**

(similar, but not identical)



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## *Protein Biosynthesis*
### *Codon Chart*

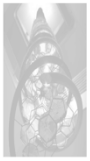
| 1st letter | 2nd Letter: U | 2nd Letter: C | 2nd Letter: A | 2nd Letter: G | 3rd letter |
|---|---|---|---|---|---|
| U | UUU Phe | UCU Ser | UAU Tyr | UGU Cys | U |
| | UUC Phe | UCC Ser | UAC Tyr | UGC Cys | C |
| | UUA Leu | UCA Ser | UAA Stop | UGA Stop | A |
| | UUG Leu | UCG Ser | UAG Stop | UGG Trp | G |
| C | CUU Leu | CCU Pro | CAU His | CGU Arg | U |
| | CUC Leu | CCC Pro | CAC His | CGC Arg | C |
| | CUA Leu | CCA Pro | CAA Gln | CGA Arg | A |
| | CUG Leu | CCG Pro | CAG Gln | CGG Arg | G |
| A | AUU Ile | ACU Thr | AAU Asn | AGU Ser | U |
| | AUC Ile | ACC Thr | AAC Asn | AGC Ser | C |
| | AUA Ile | ACA Thr | AAA Lys | AGA Arg | A |
| | AUG Met | ACG Thr | AAG Lys | AGG Arg | G |
| G | GUU Val | GCU Ala | GAU Asp | GGU Gly | U |
| | GUC Val | GCC Ala | GAC Asp | GGC Gly | C |
| | GUA Val | GCA Ala | GAA Glu | GGA Gly | A |
| | GUG Val | GCG Ala | GAG Glu | GGG Gly | G |

Central Dogma

DNA

mRNA

Protein



Several nucleic acids linked together form DNA

Three nucleic acids in a row form a codon, which codes for different amino acids

Several consecutive codons form genes

~22,000 defin
a human

**18 65**

## *DNA: Genetics & Genomics*

*Timelines*


Gregor Mendel (1822-1884)

https://www2.edc.org/weblabs/Mendel/MendelMenu.html

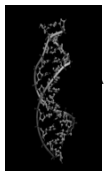
**19 53**

## *DNA: Molecular Discovel*

*X-Ray Crystal Structure*

http://info.bio.cmu.edu/courses/03231/ProtStruc/Prot

β-DNA: Rosalind Franklin



12 base sequence

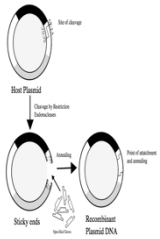
http://molvis.sdsc.edu/pdb/dna_b_form.pdb


**19 75**

## *Restriction Enzymes / Recombinant DNA*

Berg, Boyer, Cohen, and many others

http://nar.oxfordjournals.org/content/early/2013/10/18/nar.gkt990.full

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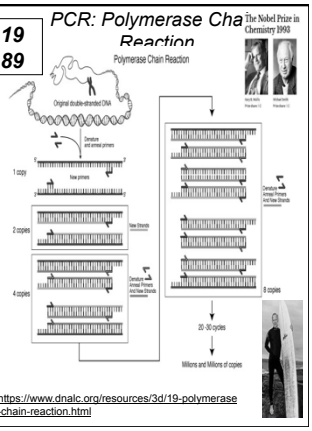
## *PCR: Polymerase Cha Reaction*



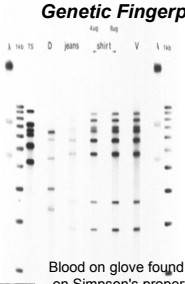

The Nobel Prize in Chemistry 1993

https://www.dnalc.org/resources/3d/19-polymerase-chain-reaction.html


Roger Salquist Chairman CEO Calgene

**19 95**

## *Genetic Fingerprinting*



Blood on glove found on Simpson's property appeared to contain genetic markers of Simpson and both victims.

OJ Simpson and the bloody glove.

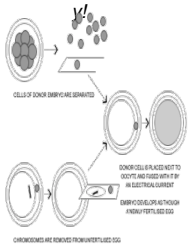

http://www.genome.gov/25019879

http://unlockinglifescode.org/timeline?tid=4

**19 96**

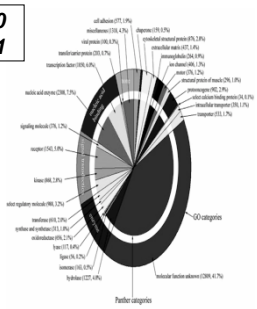
## *CLONING*

*Hello Doll y!*




**Human Genome: Distribution of the molecular functions of 26,383 human genes.**

**20 01**




J. Craig Venter et al. Science 2001;291:1304-1351

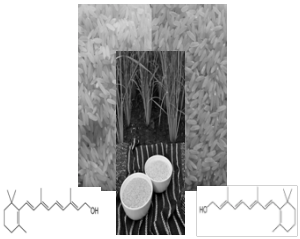
Science

Published by AAAS

**20 01**

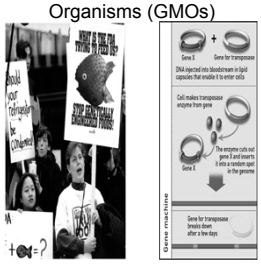
## *Golden Rice*

http://www.goldenrice.org/



Hunan Study 2008
Golden Rice Paper 2012
Patents for Humanity Awards 2015

***Transgenic Crops***
Genetically Modified Organisms (GMOs)



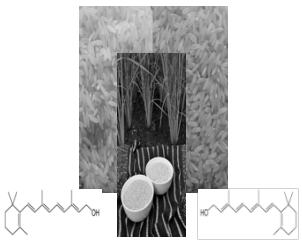
http://www.greenpeace.org/international/Global/international/publications/agriculture/2013/458%20-%20Golden%20Illusion-GE-goldenrice.pdf

http://www.i-sis.org.uk/rice.php

***2001***

***Golden Rice***

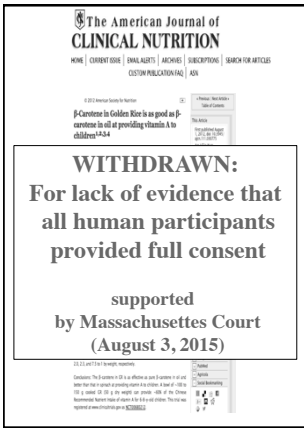
http://www.goldenrice.org/



Hunan Study 2008

WITHDRAWN July 2015

http://news.sciencemag.org/asiapacific/2013/09/golden-rice-not-so-golden-tufts



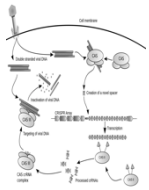

**WITHDRAWN:**
**For lack of evidence that all human participants provided full consent**

**supported by Massachusettes Court (August 3, 2015)**

***2012***

Genome Editing / CRISPR-Cas9

https://www.youtube.com/watch?v=SuAxDVBt7kQ



https://www.youtube.com/watch?v=2pp17E4E-O8

***2016***

Genome Editing / CRISPR-Cas9
**Target**
β-Thalassemia: Shortage of β-globin Protein

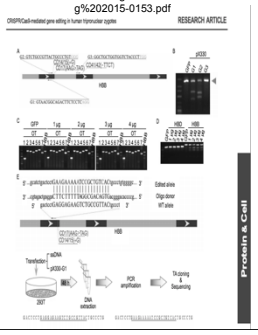
Normal β-globin

https://www.dnalc.org/resources/3d/17-sickle-cell.html

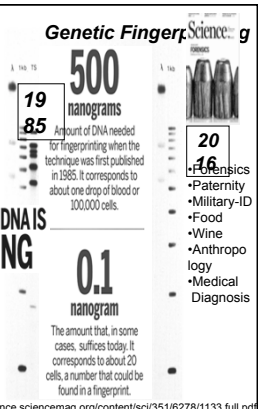
***2016***

Genome Editing / CRISPR-Cas9
β-Thalassemia / Human Embryo Research

http://chemconnections.org/general/chem121/Gene%20Editing/Gene%20Editing%202015-0153.pdf



## Genetic Fingerp… g




**19 85**

**20 16**

- Forensics
- Paternity
- Military-ID
- Food
- Wine
- Anthropology
- Medical Diagnosis

http://science.sciencemag.org/content/sci/351/6278/1133.full.pdf

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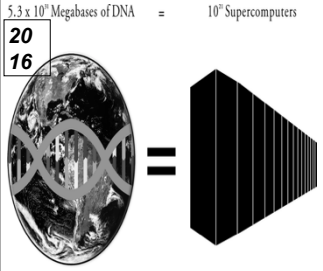
**Fig 1. Storing the total amount of information encoded in DNA in the biosphere, 5.3 × 1031 megabases (Mb), would require approximately 1021 supercomputers with the average storage capacity of the world's four most powerful supercomputers.**




**20 16**

http://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.1002168#pbio-1002168-g001

Landenmark HKE, Forgan DH, Cockell CS (2015) An Estimate of the Total DNA in the Biosphere. PLoS Biol 13(6): e1002168. doi:10.1371/journal.pbio.1002168 http://127.0.0.1:8081/plosbiology/article?id=info:doi/10.1371/journal.pbio.1002168

PLOS BIOLOGY

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**20 16**

**Table 1. The total DNA content in the biosphere**

| | DNA amount (Mb) |
|---|---|
| Prokaryotes | $1.6\ (1.1) \times 10^{31}$ |
| Unicellular eukaryotes | $1.3\ (0.9) \times 10^{29}$ |
| Fungi | $1.7\ (3.4) \times 10^{27}$ |
| Animals | $4.2\ (1.5) \times 10^{29}$ |
| Plants | $3.6\ (3.4) \times 10^{31}$ |
| Viruses | $4.0\ (3.4) \times 10^{29}$ |
| **Total** | $\mathbf{5.3\ (3.6) \times 10^{31}}$ |

doi:10.1371/journal.pbio.1002168.t001

Landenmark HKE, Forgan DH, Cockell CS (2015) An Estimate of the Total DNA in the Biosphere. PLoS Biol 13(6): e1002168. doi:10.1371/journal.pbio.1002168 http://127.0.0.1:8081/plosbiology/article?id=info:doi/10.1371/journal.pbio.1002168

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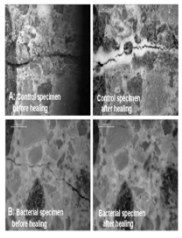
**20 16**

*Bioengineering: Structural Materials & Molecules*

Bacteria & Yeast

*Healing Concrete*

http://heronjournal.nl/56-12/1.pdf

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**20 16**

*Bioengineering: Artemisinin*

Bacteria, Yeast & Chemical Synthesis

*Chinese Wormwood (Artemisia annua) & Malaria*