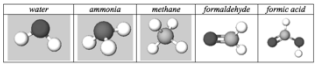
Organic Molecules
Functional Groups

Amines: Weak Organic Bases
Carbon Derivatives of Ammonia

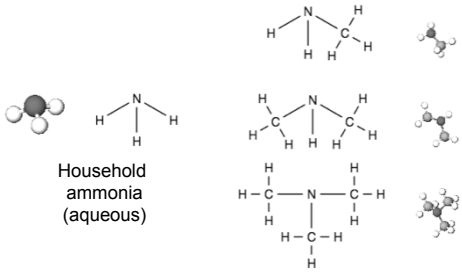
Dr. Ron Rusay

Small Organic Molecules
Common Functional Groups

Name	General Formula
Alcohols	R–OH
Ethers	R–O–R′
Amines	$R–NH_2$
Carboxylic Acids	R-C(=O)-OH

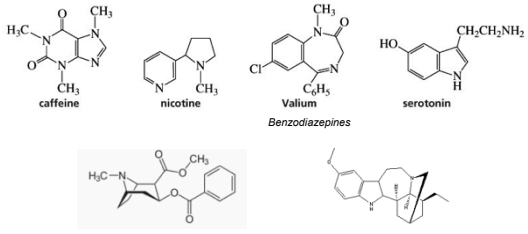


Small Organic Molecules
Ammonia & Amines

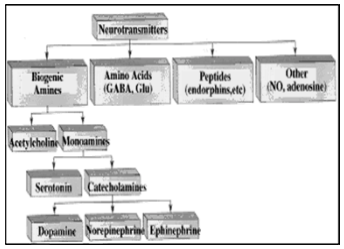


Household ammonia (aqueous)

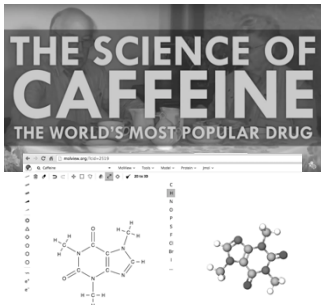
Alkaloids: Naturally Occuring Bases
Nitrogen Heterocycles



Amines & Neurotransmitters



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



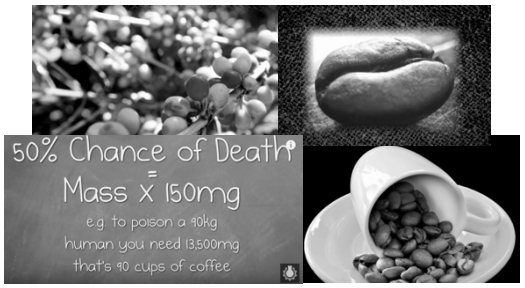
http://www.coca-cola.co.uk/stories/caffeine-counter

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

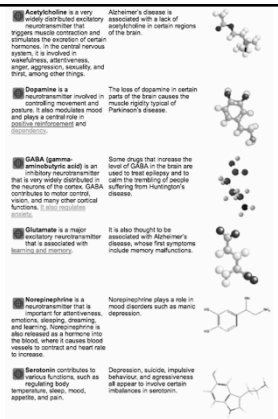
https://www.youtube.com/watch?v=OTVE5iPMKLg

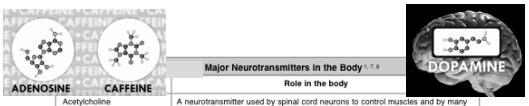
Coffee: The Greatest Addiction Ever

(A testimonial?)



Neurotransmitters

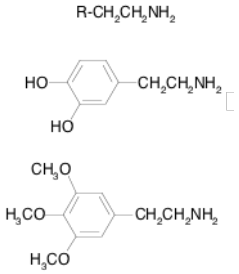




Major Neurotransmitters in the Body [1, 7, 8]

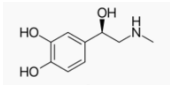
	Role in the body
Acetylcholine	A neurotransmitter used by spinal cord neurons to control muscles and by many neurons in the brain to regulate memory. In most instances, acetylcholine is excitatory.
Dopamine	The neurotransmitter that produces feelings of pleasure when released by the brain reward system. Dopamine has multiple functions depending on where in the brain it acts. It is usually inhibitory.
GABA (gamma-aminobutyric acid)	The major inhibitory neurotransmitter in the brain.
Glutamate	The most common excitatory neurotransmitter in the brain.
Glycine	A neurotransmitter used mainly by neurons in the spinal cord. It probably always acts as an inhibitory neurotransmitter.
Norepinephrine	Norepinephrine acts as a neurotransmitter and a hormone. In the peripheral nervous system, it is part of the fight-or-flight response. In the brain, it acts as a neurotransmitter regulating normal brain processes. Norepinephrine is usually excitatory, but is inhibitory in a few brain areas.
Serotonin	A neurotransmitter involved in many functions including mood, appetite, and sensory perception. In the spinal cord, serotonin is inhibitory in pain pathways.

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

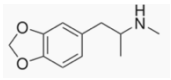


phenyl-ethylamine
dopamine
mescaline

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



Epinephrine (adrenaline)



Ecstacy (mdma)

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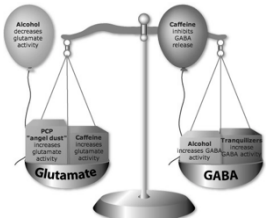
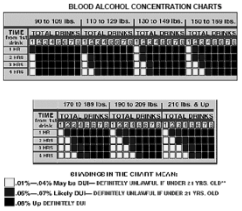
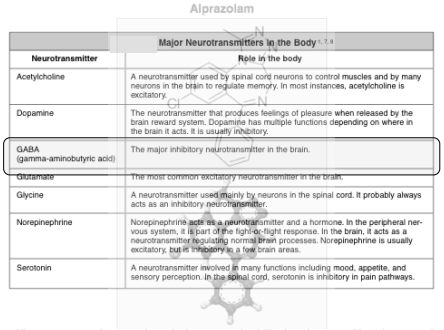


A Delicate Balance



http://www%2Drci.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



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Clinical Anxiety

How Does Xanax (Alprazolam) Work?

https://www.youtube.com/watch?v=Kq6oNcd3d-U&feature=push-u&attr_tag=LeRwov3XCoYUsxI4-6

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

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.
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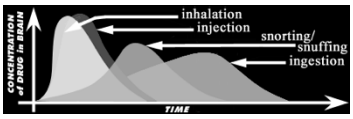
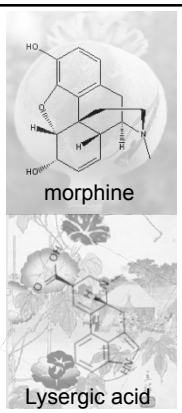
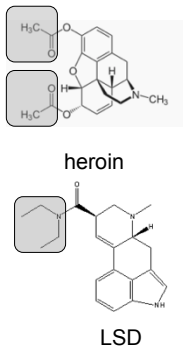
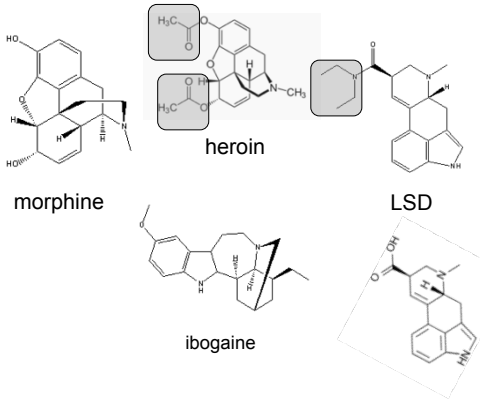
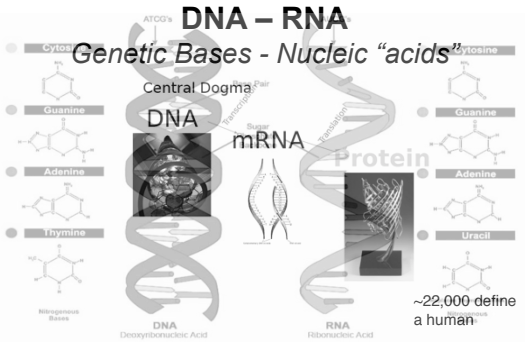


A) a<b<c<d
B) c<a<d<b
C) b<d<a<c
D) d<b<c<a









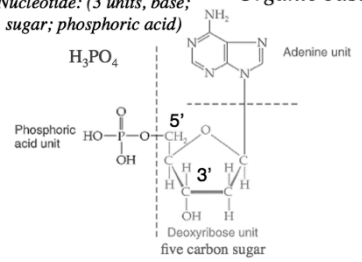
Amanda Ruby

Nucleic "Acids"

Genetic base

Organic base: R-NH$_2$

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



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).

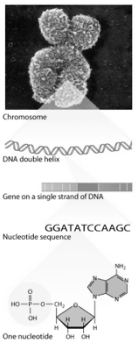
DNA & RNA: Nucleic Acids

- Store & carry genetic information.

- DNA (deoxyribonucleic acids) have molecular weights ~ 6×10^6 to 16×10^6 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**

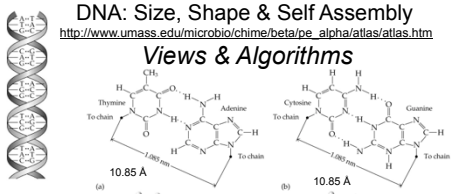


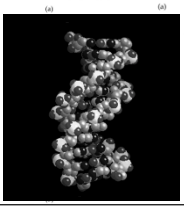
♂ **XY**

DNA: Size, Shape & Self Assembly

http://www.umass.edu/microbio/chime/beta/pe_alpha/atlas/atlas.htm

Views & Algorithms

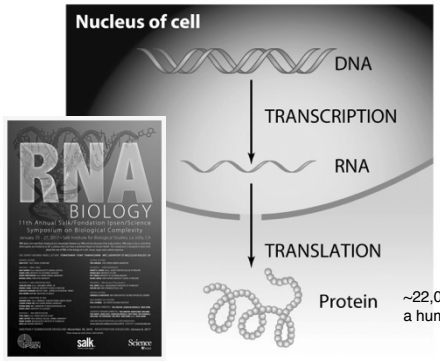




Protein Biosynthesis

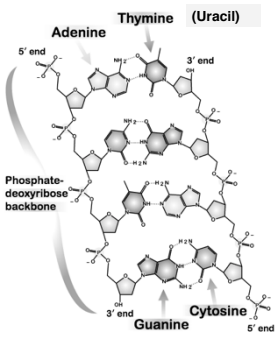
http://chemconnections.org/general/movies/PROTEIN1.MOV

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



~22,000 define a human

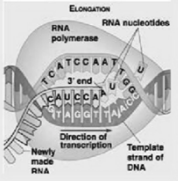
mRNA



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: GTAGGT…
mRNA: CAUCCA…

mRNA

DNA	Coding Strand (Codons)	5' > > > - - - - - - T T C - - - - - - > > > 3'
	Template Strand (Anti-codons)	3' < < < - - - - - - A A G - - - - - - < < < **5'**
mRNA	Message (Codons)	5' > > > - - - - - - U U C - - - - - - > > > 3'
tRNA	Tranfer (Anti-codons)	3' < < < A A G < < < **5'**
Protein	Amino Acid	**Amino** > > > Phenylalanine > > > **Carboxy**

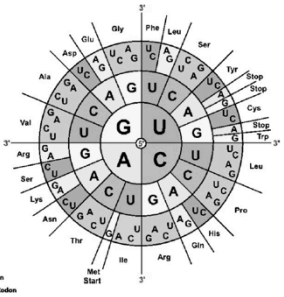
Coding Strand = Antisense strand: TTC
Anti-coding = Sense strand
mRNA: UUC

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)

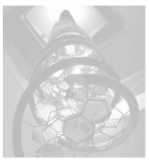


Protein Biosynthesis
Codon Chart

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

Central Dogma

DNA



Several nucleic acids linked together form DNA

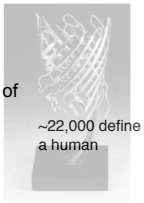
Three nucleic acids in a row form a codon, which codes for different amino acids

Several consecutive codons form genes

Genes code for a sequence of amino acids

Several amino acids linked together form proteins

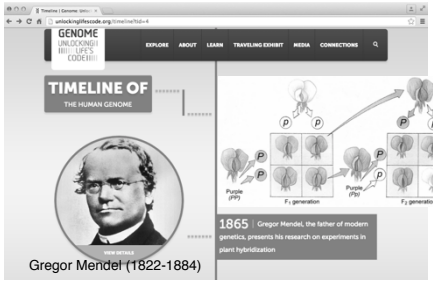
Protein



~22,000 define a human

1865

DNA: Genetics & Genomics
Timelines



Gregor Mendel (1822-1884)

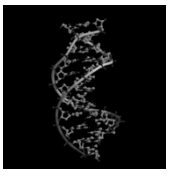
https://www2.edc.org/weblabs/Mendel/MendelMenu.html

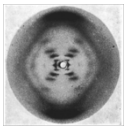
1953

DNA: Molecular Discovery
X-Ray Crystal Structure

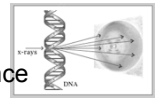
http://info.bio.cmu.edu/courses/03231/ProtStruc/ProtStruc.htm

β-DNA: Rosalind Franklin





12 base sequence



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

MOLECULAR STRUCTURE OF NUCLEIC ACIDS

A Structure for Deoxyribose Nucleic Acid

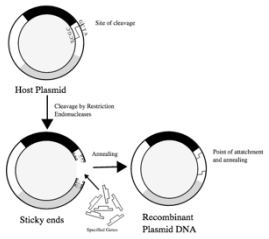
THE DOUBLE HELIX STRUCTURE OF DNA
JAMES WATSON, FRANCIS CRICK, MAURICE WILKINS, ROSALIND FRANKLIN

1975

Restriction Enzymes / Recombinant DNA

Berg, Boyer, Cohen, and many others

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

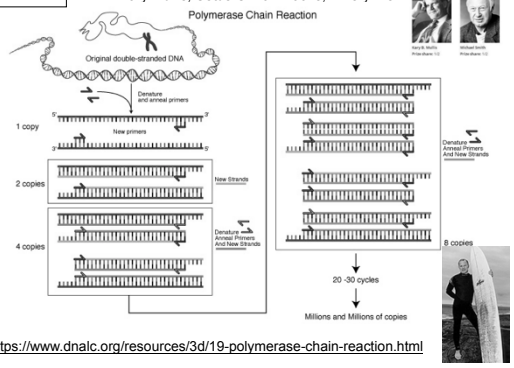


1989

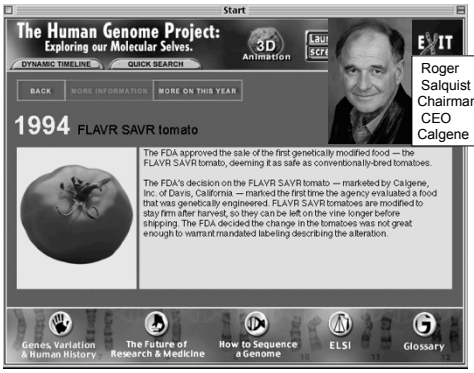
PCR: Polymerase Chain React

Kary Mullis, Cetus-Chiron-Roche, Emeryville

The Nobel Prize in Chemistry 1993



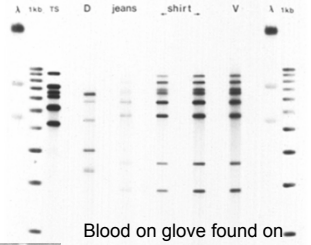
https://www.dnalc.org/resources/3d/19-polymerase-chain-reaction.html



Roger Salquist
Chairman
CEO
Calgene

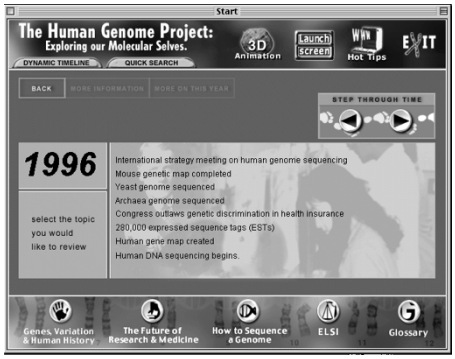
1995

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.



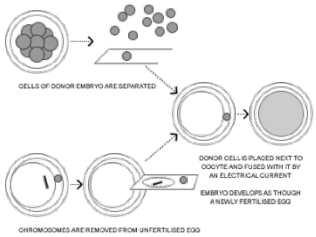
http://www.genome.gov/25019879

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

1996

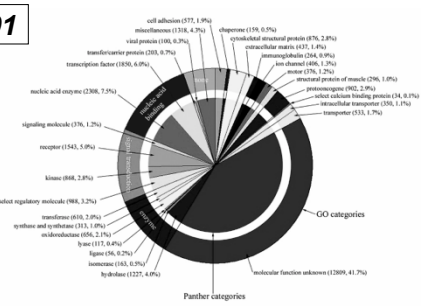
CLONING

Hello Dolly!



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

2001



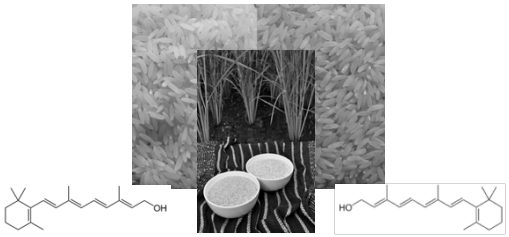
J. Craig Venter et al. Science 2001;291:1304-1351

Published by AAAS

2001

Golden Rice

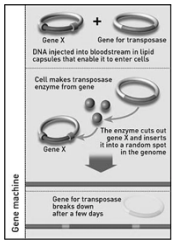
http://www.goldenrice.org/



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

Transgenic Crops

Genetically Modified Organisms (GMOs)



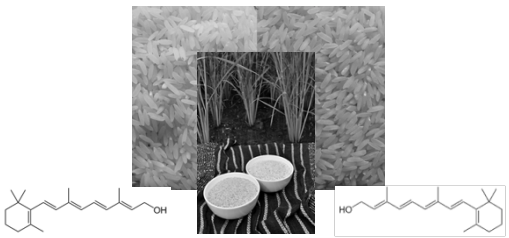
http://www.greenpeace.org/international/Global/international/publications/agriculture/2013/458%20-%20Golden%20Illusion-GE-goldenrice.pdf

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

2001

Golden Rice

http://www.goldenrice.org/



Hunan Study 2008

WITHDRAWN July 2015

Patents for Humanity Awards 2015

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

The American Journal of CLINICAL NUTRITION

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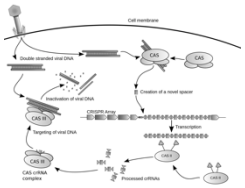
β-Carotene in Golden Rice is as good as β-carotene in oil at providing vitamin A to children[1,2,3,4]

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

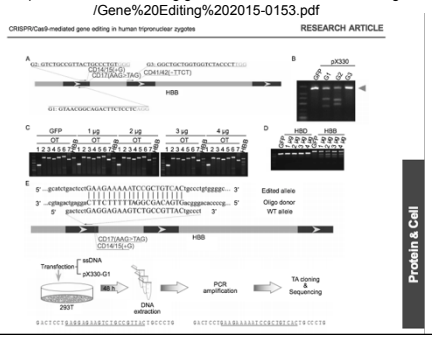
Normal β-globin

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

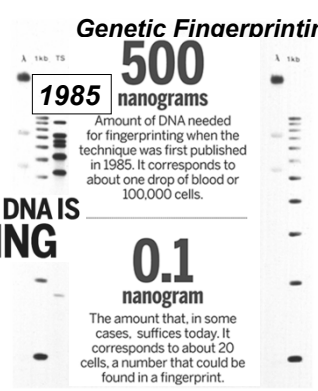
2016 Genome Editing / CRISPR-Cas9

β-Thalassemia / Human Embryo Research

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



Genetic Fingerprintir



2017

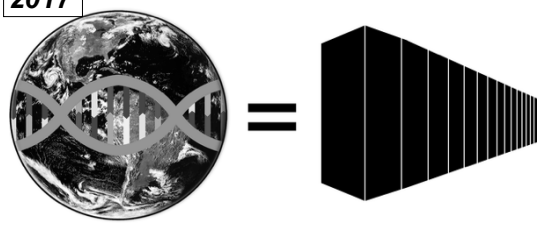
- Forensics
- Paternity
- Military-ID
- Food
- Wine
- Anthropology
- Medical Diagnosis

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

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.

5.3×10^{31} Megabases of DNA = 10^{21} Supercomputers

2017



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

2017

Table 1. The total DNA content in the biosphere

	DNA amount (Mb)
Prokaryotes	1.6 (1.1) × 10^{31}
Unicellular eukaryotes	1.3 (0.9) × 10^{29}
Fungi	1.7 (3.4) × 10^{27}
Animals	4.2 (1.5) × 10^{29}
Plants	3.6 (3.4) × 10^{31}
Viruses	4.0 (3.4) × 10^{29}
Total	**5.3 (3.6) × 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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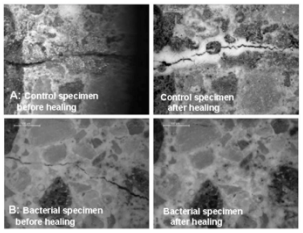
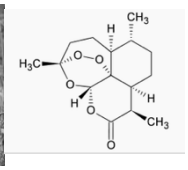
2017

Bioengineering:
Structural Materials & Molecules
Bacteria & Yeast
Healing Concrete
http://heronjournal.nl/56-12/1.pdf



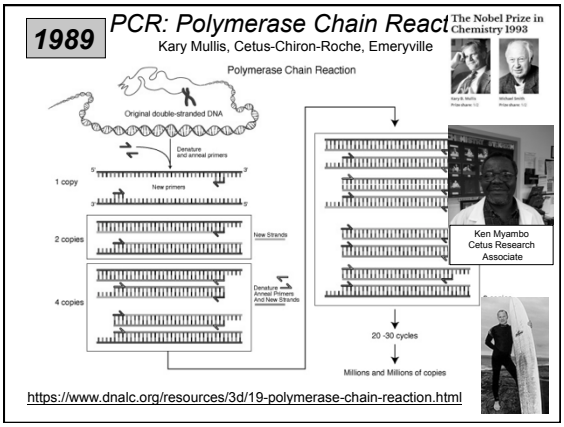
2017

Bioengineering: Artemisinin
Bacteria, Yeast & Chemical Synthesis
Chinese Wormwood (Artemisia annua)
& Malaria



1989

PCR: Polymerase Chain React
Kary Mullis, Cetus-Chiron-Roche, Emeryville



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