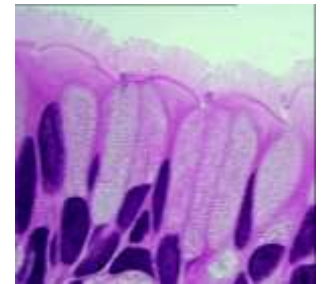
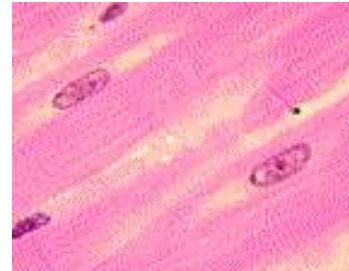
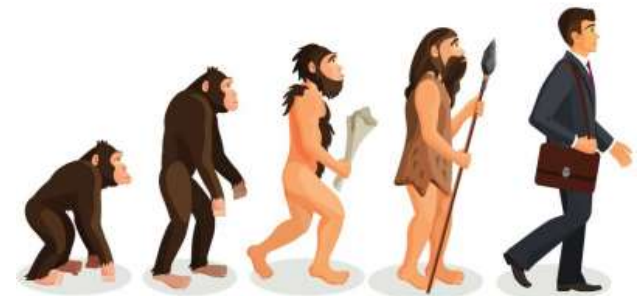


Welcome to BB101!

Your department has decided that this course is useful for you.



This is a unique course curriculum in which you are getting a broad flavor of biology. You would have to take 5-6 courses in our department to get this breadth.



BB101: Course Instructors

Swati Patankar (SP)

Office: Room 502

Biosciences & Bioengineering

patankar@iitb.ac.in

Phone: x7773



Ranjith Padinhateeri (RP)

Office: Room 306

Biosciences & Bioengineering

ranjithp@iitb.ac.in

Phone: x7761



We are friendly and approachable, but please do not harass us!

BB101: Teaching Assistants (BSBE PhD students + UG students of different depts who like biology)

Head TA: Anupama CA

D1 TAs
Abhijit Das
Haimanti Mukherjee
Swetlana Ghosh
Sudipti Shaw
Priya Sharma
Garima
Suvapriya Roy

D2 TAs
Zeenat Parween
Geetanjali Mishra
Satyajit S
Ranjit Shaw
Braja Kishor Saha
Vidyadhar
Ditipriya Mukherjee

Hindi TA (on Sundays, for anybody who needs help)

Pravallika Vemparala

We are friendly and approachable, but please do not harass us!

Introduction to Biology: before mid-sem (SP)

Before the mid-sem, we will learn about the fundamentals that enable us to think of biological organisms as living machines:

What are they made of?

What do they need to run?

How do they make copies of themselves?

How do they develop from single units into complex entities?

And most importantly, why should I care???

Text (we will upload a pdf version of this on Moodle)

Campbell Biology: Concepts & Connections

Taylor, Simon, Dickey, Hogan, Reece

9th Edition

Introduction to Biology: after mid-sem (RP)

After the mid-sem, we will learn how to use our quantitative skills to understand the physics/chemistry/engineering principles of biological organisms as living machines:

How do proteins fold?

How do molecules, cells and organisms move?

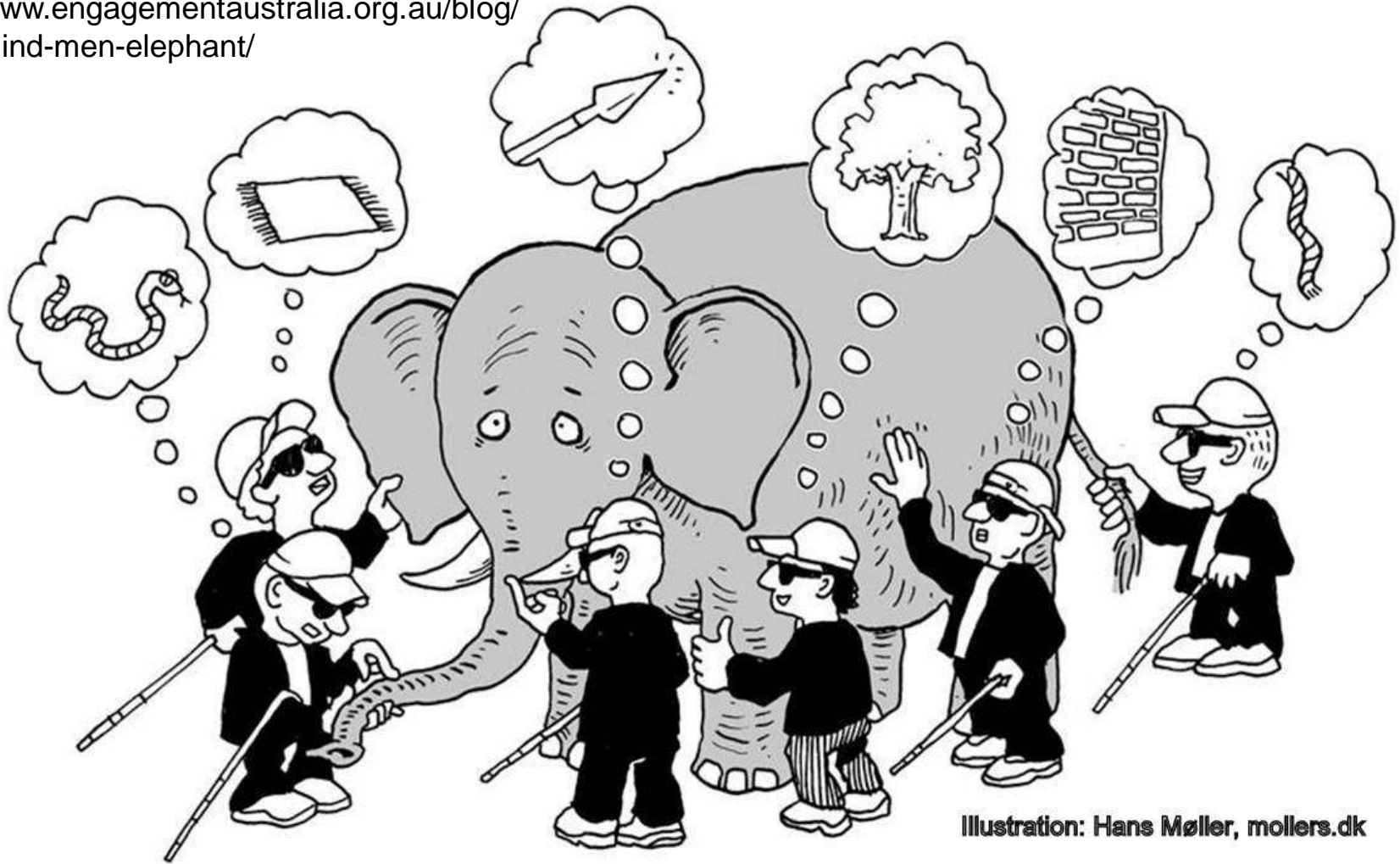
How does a heart beat?

And most importantly, why should I care???

Text (Ranjith will tell you more when he takes over)

Perception versus reality

www.engagementaustralia.org.au/blog/blind-men-elephant/



Many students hate Biology: why?

Biology is a natural science, just like Physics, Chemistry and Maths

Your impression of biology:

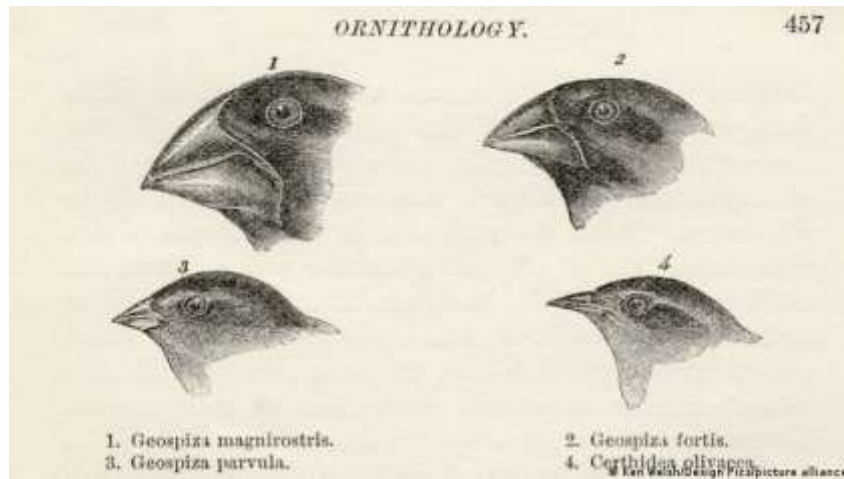
- Boring
- “Muggu”
- Drawing pictures of amoeba and paramecium
- Lots of weird names

Our job is to convince you:

- Biology has laws, rules and principles (can be understood with logic)
- Biology is highly inter-disciplinary (engineers can learn from and contribute)

Biology requires drawing skills

Charles Darwin's
drawings of biodiversity



Record
observations during
field visits

THEN

What is NOT sketched is even
more important: coloration,
texture, location, surroundings, ...



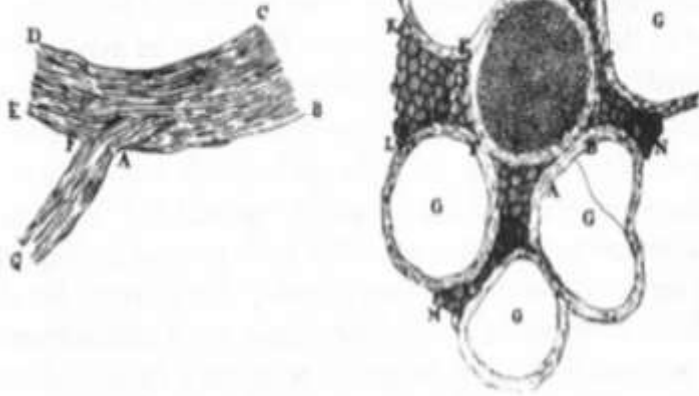
Mobile cameras, GPS, cloud
servers, ...

NOW

Biology requires drawing skills

THEN

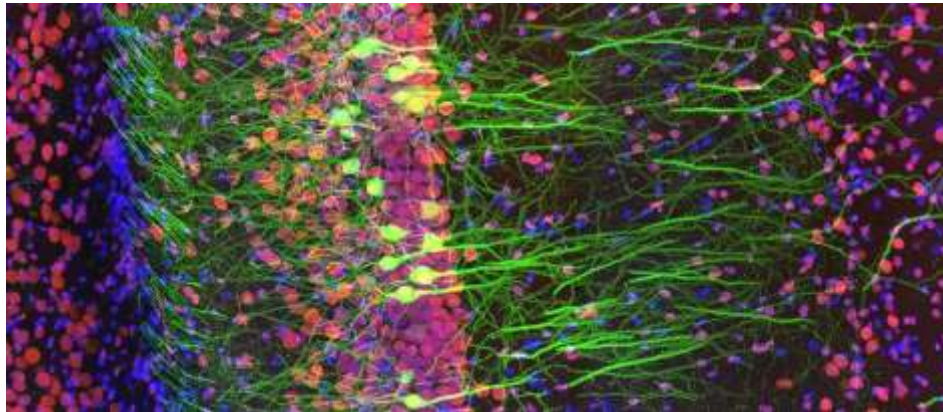
Hand drawing of plant cells



Leeuwenhoek
Microscope
(circa late 1600s)

NOW

Different cell types in the brain labeled with fluorophores)



Nikon confocal
microscope
(2018)

Winner of the Olympus microscopy images competition (titled: Neurogarden)

All sciences require learning names

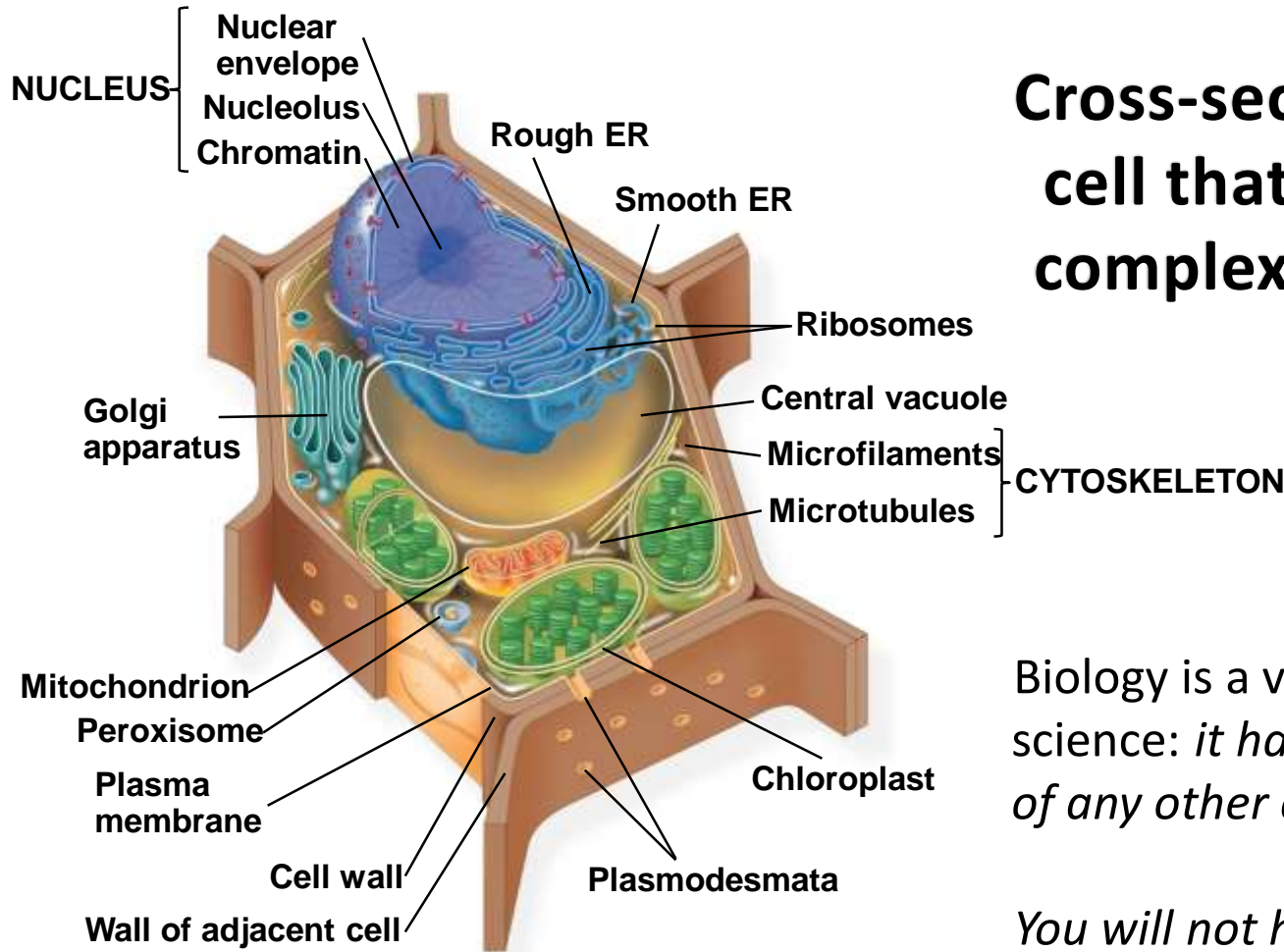
How many components does this have?



Many students want to become space scientists... are they worried about the parts list?

Do they have to memorize the name/use of each and every component or do they learn the fundamentals and apply these?

Biology also requires learning names



Cross-section of a plant cell that is even more complex than a rocket

Biology is a vocabulary-rich science: *it has to be, like the study of any other complex system.*

You will not have to memorize names, instead apply principles.

Perception vs reality

PERCEPTION

REALITY

Drawing skill

Technology has made this requirement obsolete

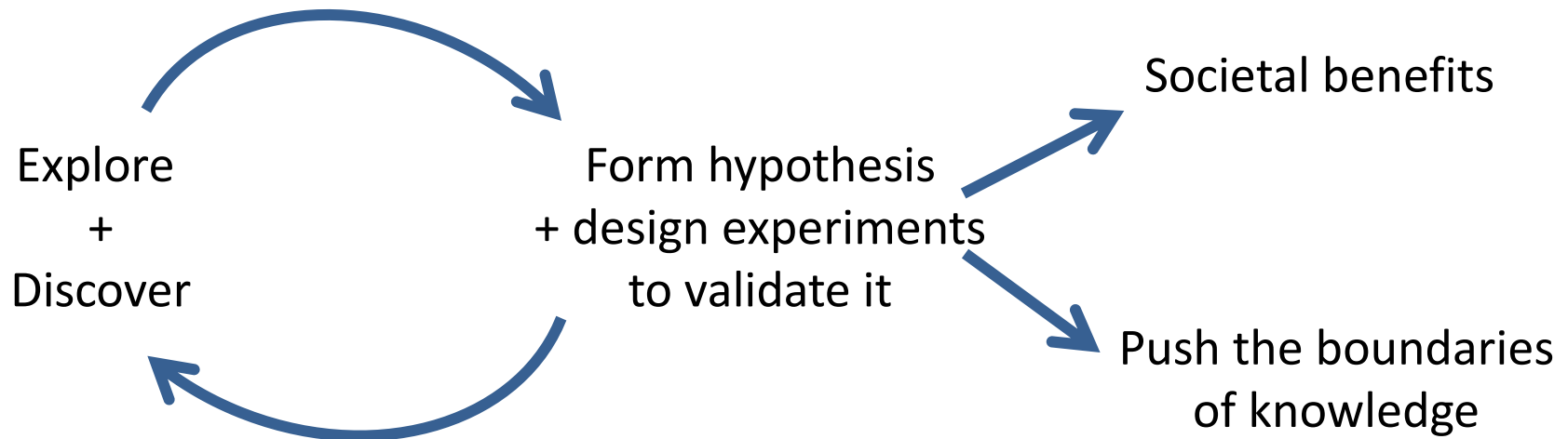
Vocabulary

Same as that for any complex system

Memorization

No more than required for the study of any other discipline

HOW MODERN BIOLOGY IS CARRIED OUT AND HOW WE WILL TEACH



Biology is the study of life

The phenomenon we call life: defies a simple, one-sentence definition

The condition that distinguishes organisms from inorganic objects and dead organisms, being manifested by growth through metabolism, reproduction, and the power of adaptation to environment through changes originating internally-From *Dictionary.com*

Why study 'life'?

Biology is the present: diabetes, heart attacks, drug/cigarette addiction, Covid-19 pandemic, etc.

Biology is the future: Covid-19 vaccine, personalized medicine, genetically modified crops, etc.

It is nice to know enough to make informed decisions for ourselves.

Objectives of this course

90% of you

Give most of you enough biology background so that you have a decent understanding as you move ahead in life

- WHY? Today and tomorrow's world is one where advances in biology will affect you every day
- We will use these futuristic scenarios in class and tutorials

10% of you

Convey to some of you the excitement of biology

- WHY? You can use your engineering background to contribute to biology and biomedical research



VIVEK JAYARAMAN

Lab Head

[Jayaraman Lab](#)

[Contact Me](#)

Vivek studied to be an aerospace engineer, and spent a few fun years developing numerical simulation software for The MathWorks. A couple of excellent neuroscience courses at Brandeis University convinced him to study brains instead. He now spends his time trying to understand bugs that are a bit more fun to work on than the ones he encountered in his previous career.

B.Tech., Indian Institute of Technology, Bombay (1994)

MS, University of Florida, Gainesville (1996)

PhD, California Institute of Technology, Pasadena (2006)



Projects

Lab
Members

Publications

Joining the
Lab

Lab News

Contact Us



Malik Lab Members

Dr. Harmit Malik

Harmit Malik grew up in the city of Bombay (now renamed Mumbai) in India. He attended the Indian Institute of Technology where he received a degree in Chemical Engineering. There, he was introduced to molecular biology thanks largely to the generous mentoring of Dr. K. Krishnamurthy Rao in the nascent Biotechnology Center. He then joined the Ph.D. program in Biology at the University of Rochester, under the mentorship of Tom Eickbush, studying the evolutionary origins of retrotransposable elements. He then arrived in Seattle to work on the evolution of centromeric histones and other assorted problems in Steve Henikoff's lab, funded by a postdoctoral fellowship from the Helen Hay Whitney Foundation. Tired of moving and because he is such a Mariners fan, he decided to stay at the Hutch after his postdoctoral term and started his lab in fall of 2003!

Harmit is interested in a variety of problems that could all be classified under the genetics of evolutionary conflict. He studies rapidly evolving proteins as a hallmark of this kind of conflict, hoping to better understand the molecular nature of the conflict, as well as uncover previously unrecognized sources of conflict. His lab is currently working on several rapidly evolving projects—including centromeres and heterochromatin, nuclear import and variant histones, and innate defense strategies against retroviruses. Harmit's role in the lab ranges from supervising the projects of other lab members to serving as their glorified technician.

Harmit is married to Chandni and has two young sons, Aman and Vivek. He used to be an avid reader of comic books and graphic novels. After Aman and Vivek, he is getting interested in linguistic studies of toddlers!



Principal Investigator
Fred Hutchinson Cancer Research
Center

What is Biology?

Botany

Zoology

Microbiology

Molecular Biology

Neurobiology

Physiology

Biochemistry

Geology

Bioinformatics

Biotechnology

Biophysics

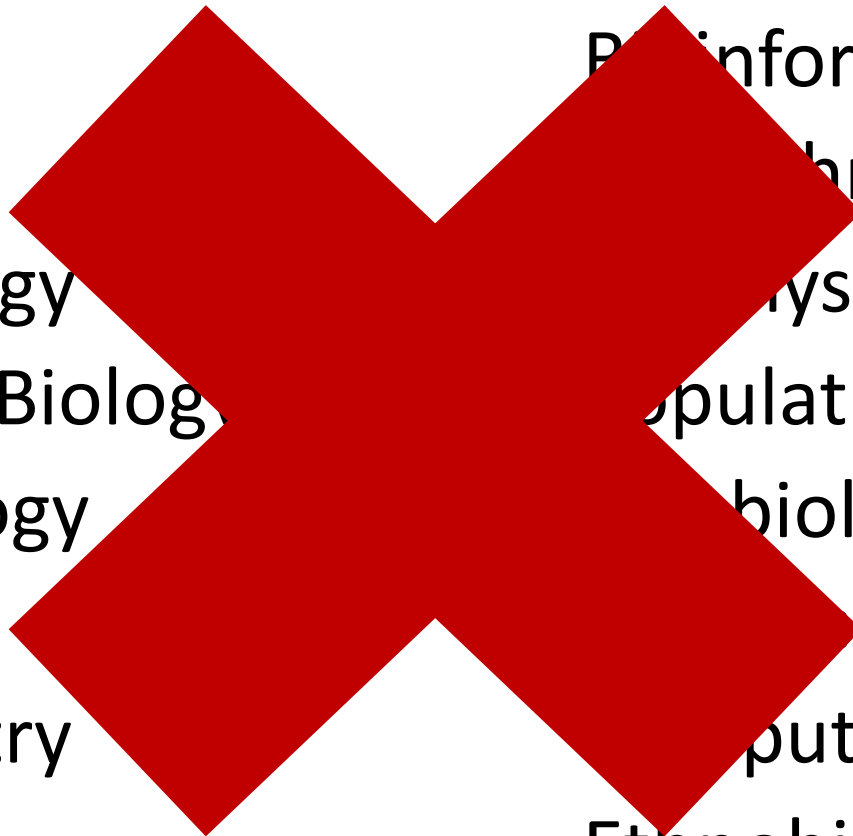
Population biology

Immunobiology

Plant biology

Computational biology

Ethnobiology



What is Biology? The study of Life

Take a walk and what do you see?

Trees

Insects

Soil

Humans

Water

Birds



How do trees know when to shed their leaves?

Why do insects make a chirping noise?

Do any creatures live in the soil?

What makes every human different from each other?

Can birds communicate with each other through song?

As with all science, in
biology there are
interesting questions....

We try and find the answers by using
different approaches that could involve study
of behavior, populations, tissues, molecules,
and even physics and chemistry.

A modern crime thriller

Latha Reddy



(Photo credit: BBC News)

Delivers a baby boy in Nayapul Government Maternity Hospital, Hyderabad (2003)

Is given a baby girl on discharge from the hospital

Baby swapping racket uncovered

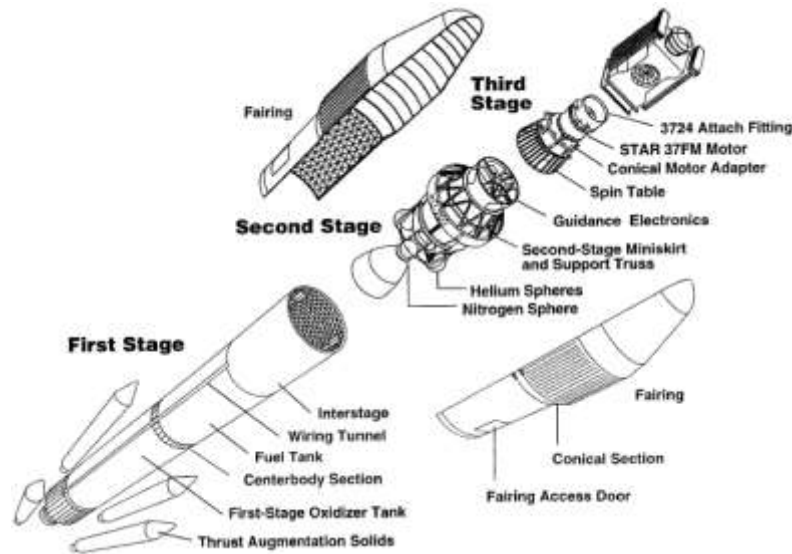
Can we say with certainty that a child is the offspring of his/her parents?

**Before we can begin to answer
interesting questions....**

**Let us look at the
approaches used**

Approaches to studying complex systems: bottom-up approach

(used in engineering)



(stardust.jpl.nasa.gov)

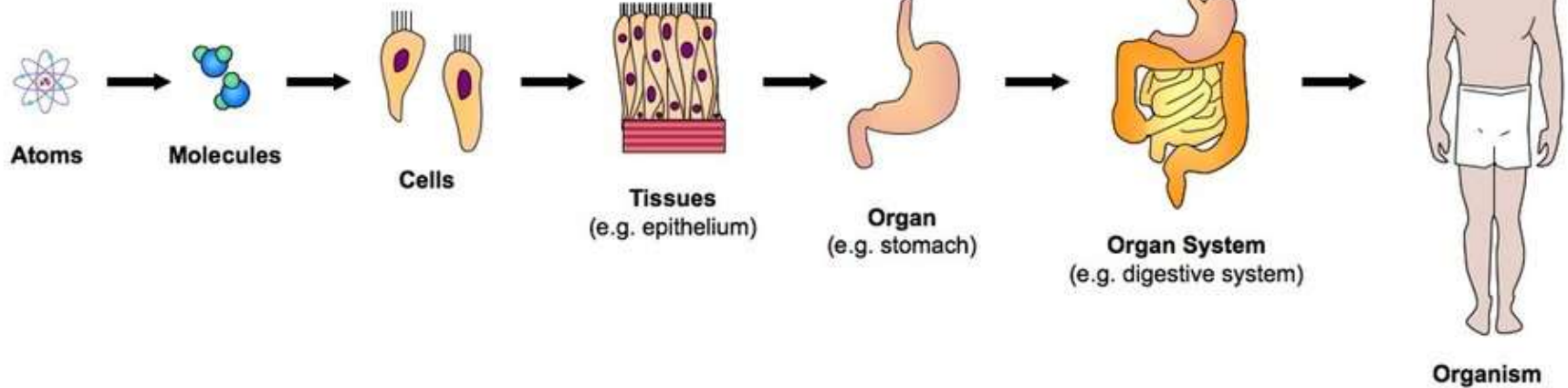


(www.orbital.com)

Information on parts
and design available
in a manual

Use manual
to construct
rocket

Approaches to studying complex systems: top-down approach



Try to reach this



Start with this

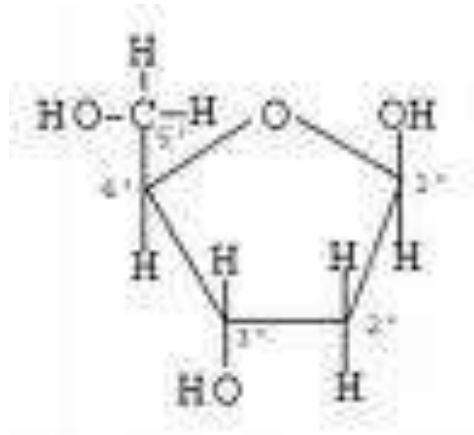
Living organisms are more complex than the rocket!
Do they have a manual (instruction booklet) as well?

DNA is the 'manual' for life

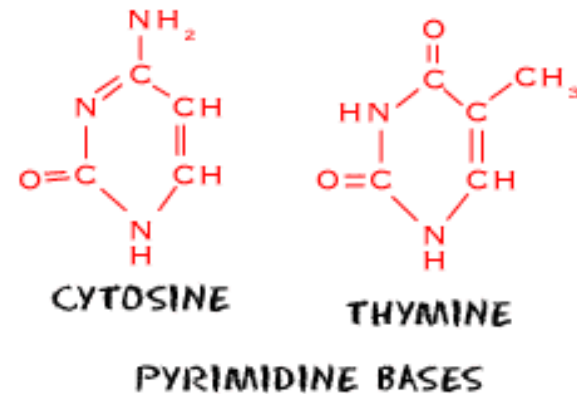
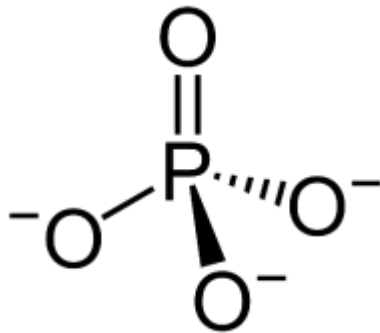
(DNA: deoxyribonucleic acid)

Components of DNA

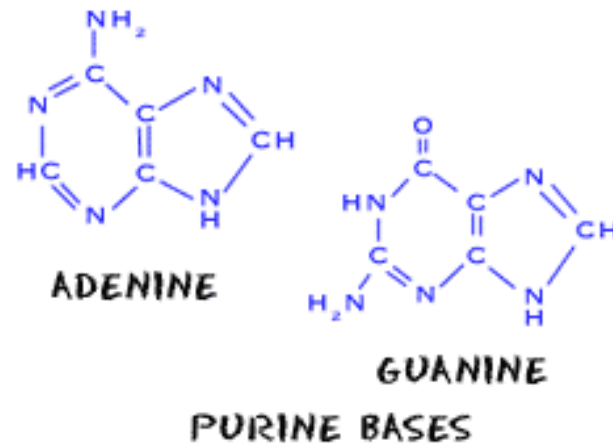
Deoxyribose sugar



Phosphate



Nitrogenous bases: A, T, G, C



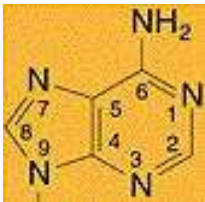
DNA is chemically like Coca Cola...

.... but DNA carries information

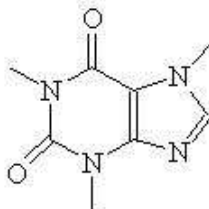


Coke	DNA	Solubility
water	water	-
Sugar (sucrose)	Sugar (deoxyribose)	VERY High
Phosphate (PO ₄ ⁻ acid)	phosphate	moderate
caffeine	bases (A,T,C,G)	extremely low

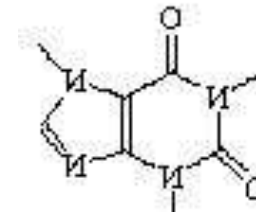
http://www.cbs.dtu.dk/staff/dave/DNA_coke-1.htm



adenine

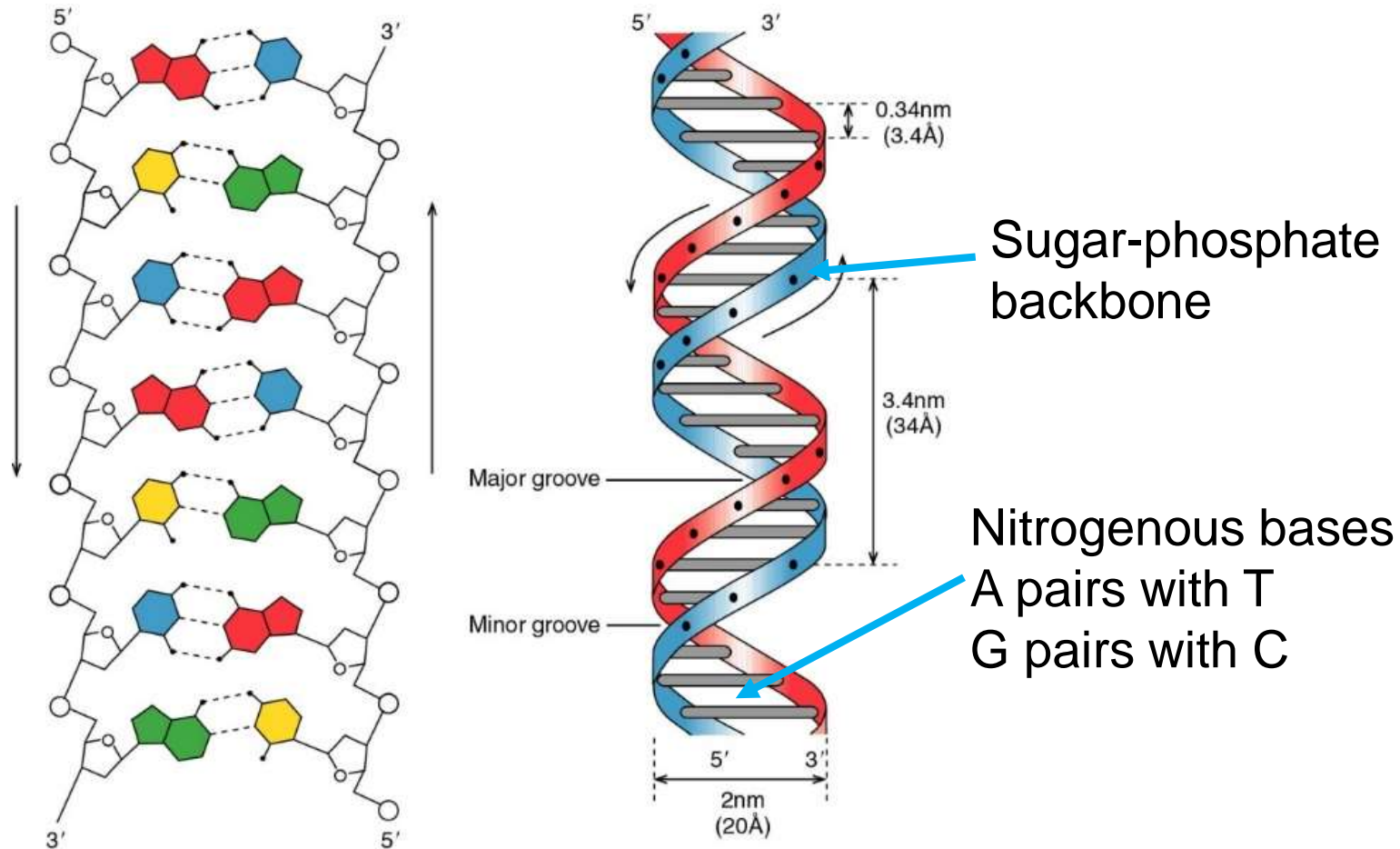


caffeine



inverted structure of caffeine

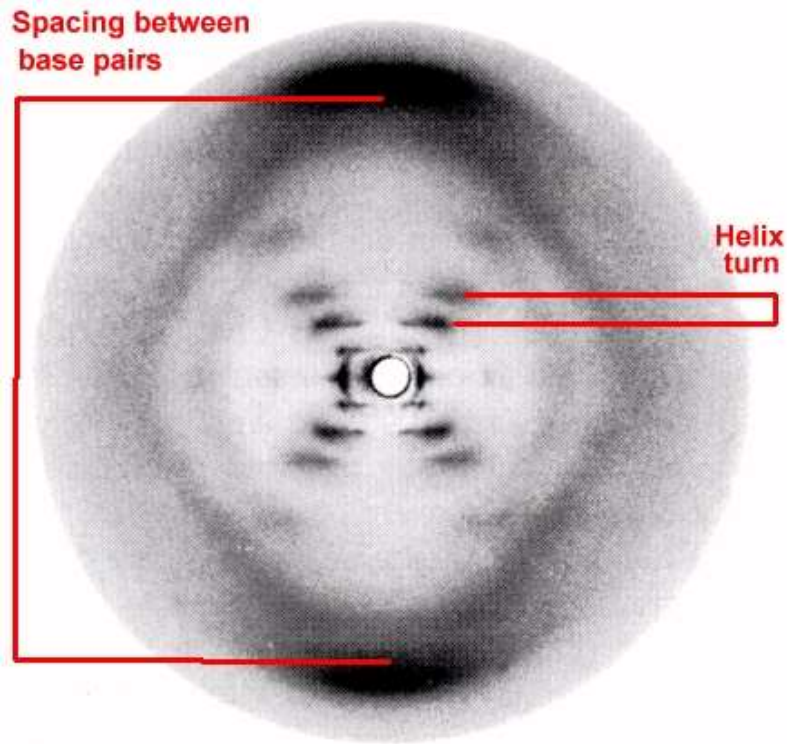
Structure of DNA: a double helix



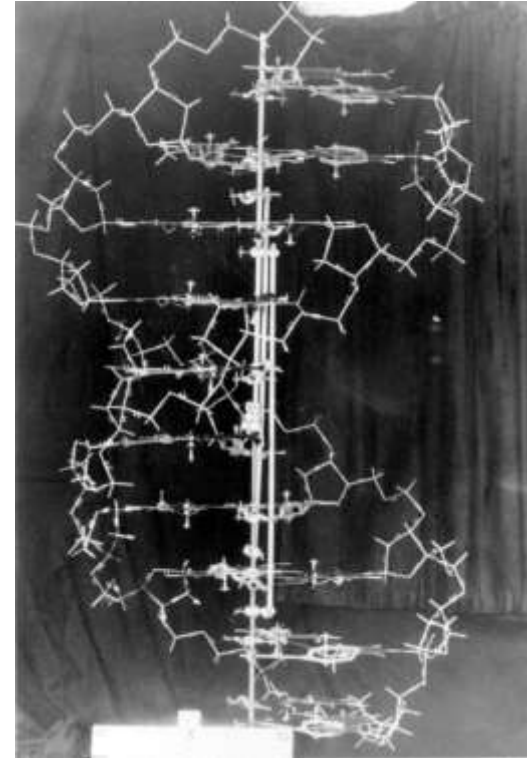
One strand of DNA is represented like this:

5'.....ATTGCGATACGCATAGCCGGTTACACTTCAGAT.....3'

Solving the structure of DNA: X-ray diffraction (physics) combined with models (chemistry)

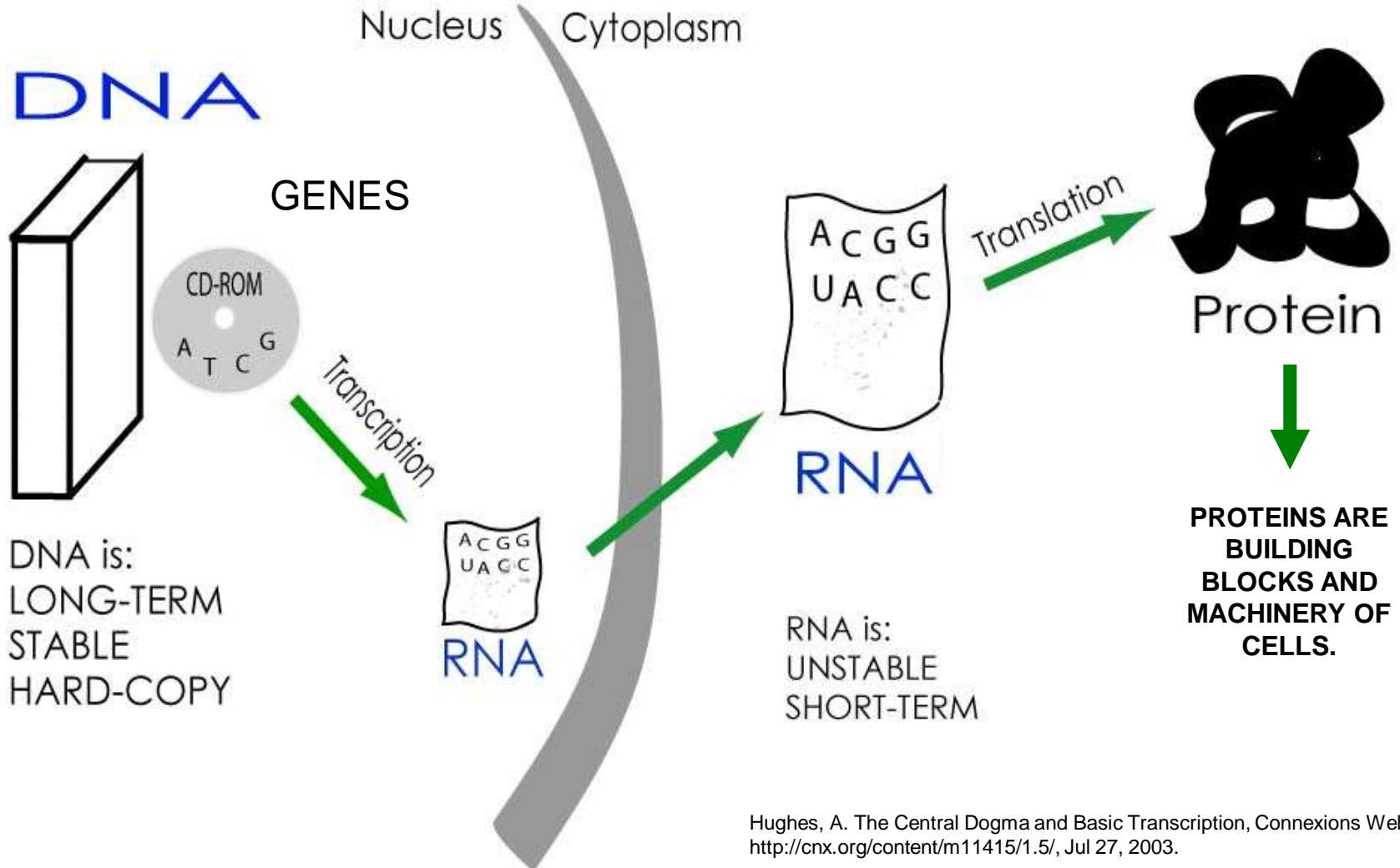


X-ray diffraction data: Rosalind Franklin and Maurice Wilkins



Ball and stick models: Watson and Crick

How can DNA be a manual? The Central Dogma



Hughes, A. The Central Dogma and Basic Transcription, Connexions Web site.
<http://cnx.org/content/m11415/1.5/>, Jul 27, 2003.

Our (human) DNA manual is huge: ~ 3 billion base pairs



Phage λ
50 kb
2 pages



Escherichia coli
(bacteria)
4.7 Mb
200 pages



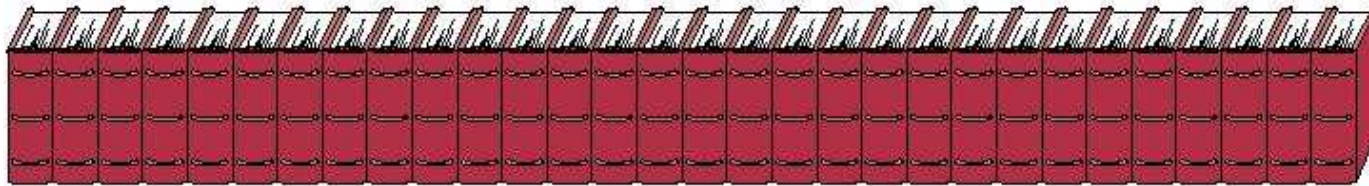
Saccharomyces cerevisiae
(yeast)
12.5 Mb
500 pages



Caenorhabditis elegans
(nematode)
Arabidopsis thaliana
(plant)
100 Mb
3 volumes



Drosophila melanogaster
(fruit fly)
165 Mb
5 volumes



Human being
3000 Mb
80 volumes



25 kb per page
1500 pages
per volume
(2 inches thick)

Sequence of the human genome is known

- Human genome ~ 3 billion bases
...ATGCAATCCGTGCAT...
- We now know the DNA sequence of the entire human genome
- Joint effort between Celera Genomics and Human Genome Sciences



How can all this stuff help Latha?

There are differences between individuals at the DNA level:

- Siblings differ by 1 to 2 million bases, ~99.98% identical
- Unrelated humans differ by 6 million bases, ~99.8% identical
- Chimpanzees differ from humans by about 100 million base pairs ~98% identical
- Baboons differ from humans by about 300 million base pairs ~92% identical
- Mice differ from humans by about 2.8 million bases, but regions that encode information for proteins are ~90% identical
- Leaf spinach differs from humans by about 2.9 million bases, but regions that encode information for making proteins are ~40% identical

DNA variations: single nucleotide polymorphisms (SNPs)

SNP1

SNP2

1....ATCCTGT **A** CCTACGTGTACAATAGTA....CTGATCA **T** CTCTATGGG....
2....ATCCTGT **T** CCTACGTGTACAATAGTA.... CTGATCA **T** CTCTATGGG....
3....ATCCTGT **A** CCTACGTGTACAATAGTA....CTGATCA **G** CTCTATGGG....



In the flower shop, Shyanne and her mommy turned the corner and in the middle of the floor sat a blue cow eating daisies! Shyanne stopped and stared.

The blue cow did not notice anyone looking at him. He kept on eating and eating and eating.

As Shyanne went to pass the blue cow, it rolled over and burped.

Shyanne stopped and said, "What should you say?"

"Excuse me for my bad manners," hiccupped the cow.

"That's okay. Will you come to my house?" Shyanne asked.

"That sounds like a wonderful idea," replied the blue cow.

Leaving the store, a funny looking horse sat blocking the door.

"Excuse me," Shyanne said, "may we pass by please?"

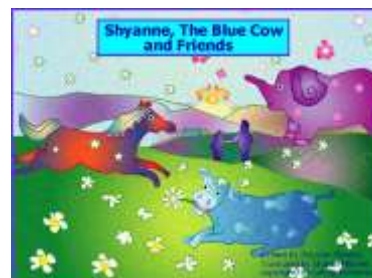
"I'm sorry, I must have fallen asleep," replied the horse with a wide yawn.

"Where are you going?" Shyanne asked the horse.

"I was on my way home," answered the sleepy horse, "but I think I missed my bus."

"Would you like to walk with us to my house?" Shyanne asked.

"Thank you, I will," replied the horse.



Author: [Deborah Roberts](#)

Illustrator: [Sharon Holmes](#)

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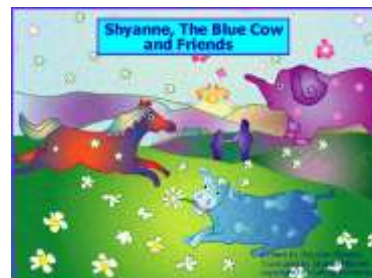
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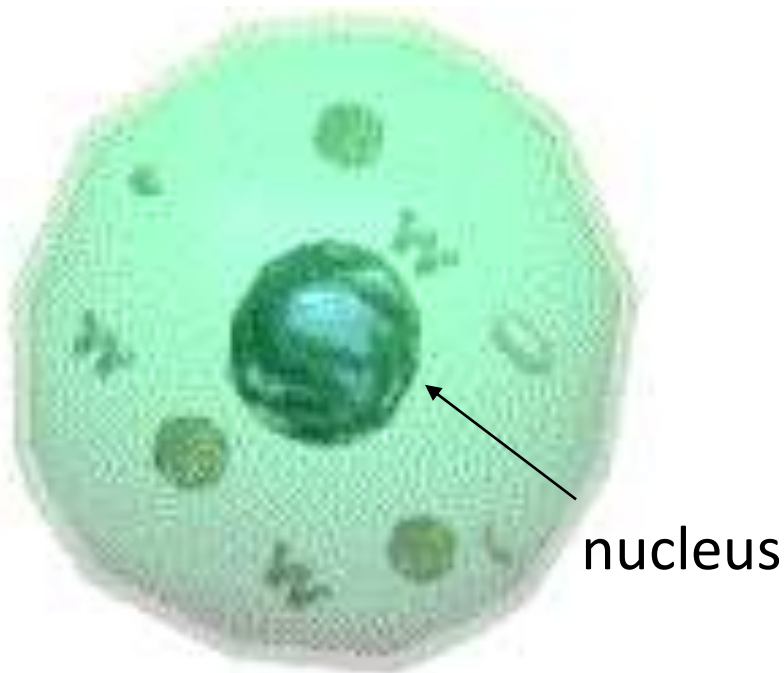


Author: [Deborah Roberts](#)

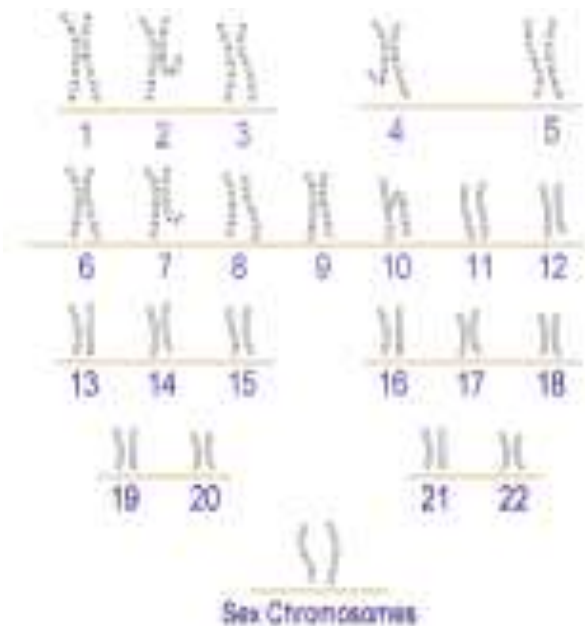
Illustrator: [Sharon Holmes](#)

In humans, our DNA is found as 23 pairs of chromosomes

A typical eukaryotic cell

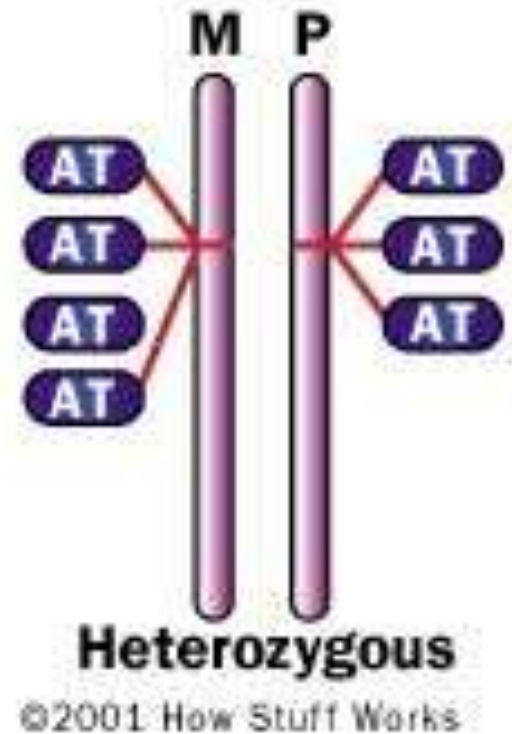
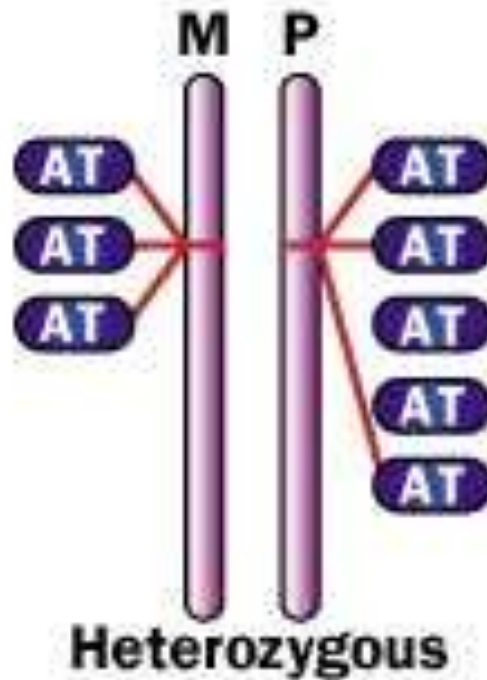
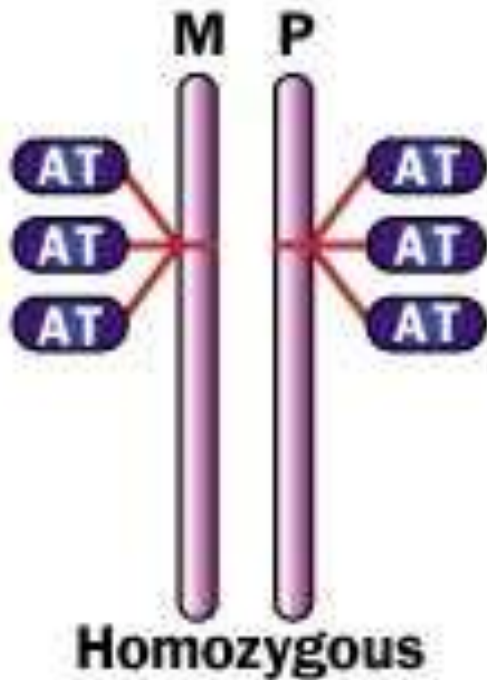


Chromosomes



The nucleus contains chromosomes which consist of coiled DNA. In a pair of chromosomes, one came from your mother (M) and the other from your father (P).

DNA variations: variable repetitive elements



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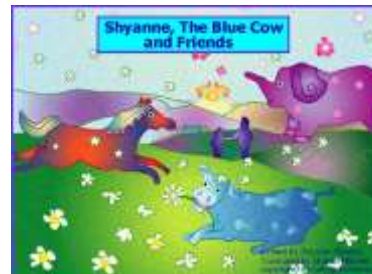
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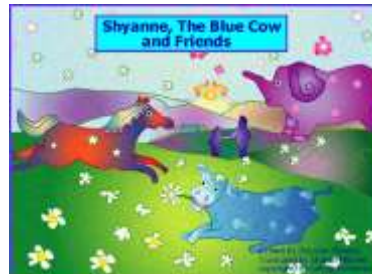
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Author: [Deborah Roberts](#)

Illustrator: [Sharon Holmes](#)



Using this information can Latha Reddy's son be identified?

A nurse in the hospital confessed that a baby boy was Latha's son.

Analysis of variations in the DNA of Latha and the baby boy showed that he was her biological offspring.

This is known as DNA fingerprinting

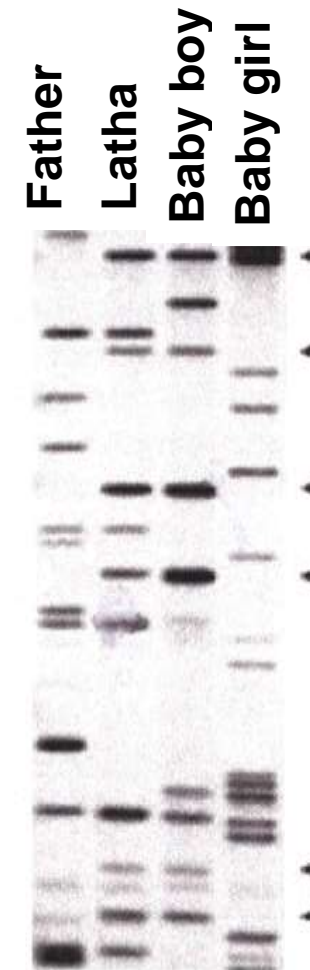


An example of DNA fingerprinting (using variable repetitive elements)

A 'bar code' for each of us!



Which of the babies is
Latha's biological offspring?



Today we can sequence whole genomes



Per genome: the cost has dropped from USD 10 million for the first genome, to ~USD 1000 today; the time has dropped to days



Oxford Nanopore DNA sequencer can be plugged into your laptop and has been used in space!

Engineering and instrumentation

Sequencing data looks like this...



Are there words and paragraphs? Is there punctuation?
What does it mean?

This requires skills similar to computer scientists at Google who work on language translation, search engines and text mining.

Computational biology

DNA can be a business: 1000s of genome sequencing companies in the UK and USA



Illumina: sequencing services, instruments and reagents for genome sequencing; 2021 revenue of \$4.52 billion and a market cap of \$28.92 billion.

Services: Ancestry, Traits, Health



Genome companies in India

[Indian Biosciences](#) (genealogy, health, immigration paternity, relationships)

[GeneSupport](#) - a collaborative venture of [geneOmbio Technologies](#) and Resilient Cosmeceuticals Pvt Ltd, with international ties with [DNALife](#) (health, lifestyle, nutrigenomics, pharmacogenetics)

[Mapmygenome](#) (health, inherited cancer gene screening, pharmacogenetics, pre-natal screening, preconception screening, exome sequencing)

[Meragenome](#) (health)

[X Code Life Sciences](#) (health)

Haystack Analytics (infectious diseases): go visit them at the IITB incubator (SINE)!

We've talked about one interesting question in biology

What makes all of us different from each other?

Ans. Variations in our DNA

- Applications in forensics,
- Study of the cause of various diseases,
- Population biology and ethnicity,
- And many more ...

Biology is interdisciplinary

Some examples from this lecture:

- **Structure of DNA (chemistry, physics)**
- **Sequencing (instrumentation and engineering, computational skills)**
- **Other examples (from IITB engineers):**

Covid-19 point of care diagnostics

Covid-19 pooling of samples for rapid diagnosis

And many more.....

So, want to know more about modern biology?

What is the difference between Covaxin and Covishield?

My cousin has leukemia and there is a new treatment based on immunotherapy. Should she take this?

My uncle has diabetes. Why is the home test for blood glucose so expensive?

Can I make a cheaper test?

If you want to know the answers, you are ready for BB101!

BB101: Schedule Fall 2022

Start of classes for new entrants: 7th August (Monday)

Mid sem: 16th September (Saturday) to 24th September (Sunday)

BB 101 (section - D1) - Biology

6A - Wed - (Class Room : LH 101) - 11:05:00 - 12:30:00

6B - Fri - (Class Room : LH 101) - 11:05:00 - 12:30:00

Tutorials: slot 3C (Thursdays 8:30 am to 9:25 am)

LT 201, 202, 203, 204, 205

BB 101 (section - D2) - Biology

10A - Tue - (Class Room : LC 101) - 14:00:00 - 15:25:00

10B - Fri - (Class Room : LC 101) - 14:00:00 - 15:25:00

Tutorials: slot 4A (Mondays 11:30 am to 12:30 pm)

LT 301, 302, 303, 304, 305

2023 AUGUST

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
		1	2	3	4	5
6	7 START	8 D2: Intro	9 D1: Intro	10	11 D1, D2: Cells	12
13	14 T2: Intro + Cells	15 D2: Holiday	16 D1: No class	17 T1: Intro + Cells	18 D1, D2: Heredity	19
20 Hindi tut	21 T2: Heredity	22 D2: Genetic material	23 D1: Genetic material	24 T1: Heredity	25 D1, D2: Flow of information	26
27 Hindi tut	28 T2: Gene + flow	29 D2: Reg of exp	30 D1: Reg of exp	31 T1: Gene + flow		

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2023 SEPTEMBER

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
					1 D1, D2: Cell communication	2
3 Hindi tut	4 T2: Reg of exp + comm	5 D2: Dev	6 D1: Dev	7 T1: Reg of exp + comm	8 D1, D2: Immune	9
10 Hindi tut	11 T2: Dev + Immune	12 D2: Metabolism	13 D1: Metabolism	14 T1: Dev + Immune	15 D1, D2: Evolution	16 Mid-sem starts
17	18	19	20	21	22	23
24 Mid-sem ends	25	26	27	28	29	30

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Bioscience & Bioengineering 101 (SP section)

Structure of the course (for each division)

Every week:

- Two lectures: Will cover the topics and give you some idea/clues about the quizzes and exams.
- One tutorial: Will include discussions about the lecture topics and end with a quiz
- Quizzes (5): 5 marks each (we will take best 4 marks out of 5 quizzes, so 20 marks from quizzes)
- Mid semester exam: 30 marks (SP)
- Attendance: Not mandatory! You are grown-ups (?) and can decide whatever you want to do
- **Moodle: lecture slides will be uploaded every week on Wed & Fri at 5 pm; all announcements will be via Moodle so keep checking it; we will try blogging on Moodle also**