Stem Cells: Science & Society

We will begin @ 6:10!

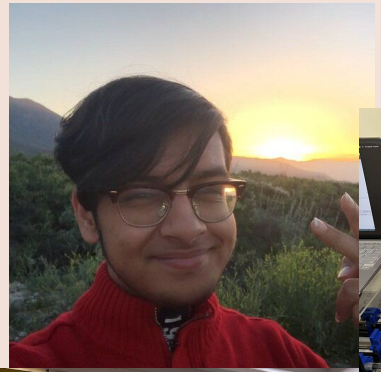
Agenda

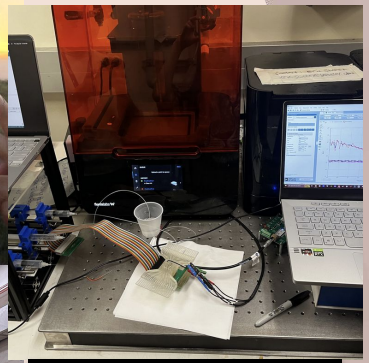
- Facilitator introductions
- Course policies & expectations
- Introduction to Stem Cell Biology

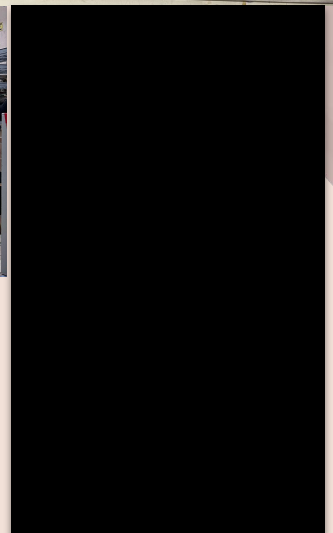
Introductions

Your Facilitators

Ronit Nath







4th Year Philosophy Major, MD/PhD Intended

Affiliated research groups:

1. Nanotechnology Laboratory (Berkeley)
2. Axions Laboratory (Berkeley)
3. Vanguards Medical Datascience (Mayo)
4. Baylink Lab (Loma Linda Medical University)

Affiliated organizations:

1. Open Computing Facility (Compsci)
2. Space Enterprise at Berkeley (Rocket engineering)
3. American Physician Scientists Association

Hobbies: Learning Languages, 3D printing, Hiking, Webnovels

Marcela Perez

Year: Fourth-year

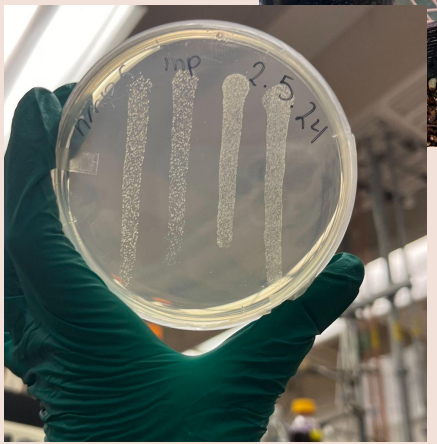
Major: Molecular & Cell Bio: Biochemistry

Professional Interests: Applying for Masters in Biotech in Fall, PhD in Molecular Biology

Research Interests: Currently working in Almeida Lab (Ecology) focusing on how physiological changes impact bacteria that causes plant disease

Likes: Running/Gym, Baking, Crocheting

What section do you teach? Wednesdays 3-4 pm



Atticus

Year: Second-year

Major: Neuroscience

Professional Interests: PhD

Research Interests: Policymaking, Equal Education Opportunity, Genetic Disorders

Likes: traveling, singing, reading, walking my dog, and playing trombone in Cal Band

What section do you teach?

Wednesday

Course Introduction & Expectations

LECTURE	Monday 6-7 PM Wheeler 102 CCN: 22137		
DISCUSSION #	**DETAILS**	**FACILITATORS**	**CCN**
011	Wednesday 3-4 PM Wheeler 126	Atticus Marcela	22138
012	Friday 12-1 PM Dwinelle 247	Ronit	22139

Modules

1. Biology of Stem Cells
2. Bioengineering & Technology
3. Ethics & Controversy
4. Policy & Advocacy

*** Each of these has a Discussion **Board** associated with it, you just have to participate in ¾ of these! Note that this is not the same as your Discussion **Section** participation.

Course Format

Lecture - *In Person (unless otherwise specified)*

- Guest lecture!
  - Usually Bay Area researchers sharing their research and knowledge
- Great opportunity to ask questions
- **Reflection** prompt given in lecture
  - Can post response in discord or to the assignment on bcourses

Discussion - *In person*

- Clear up anything confusing from lecture
- Going over the current material from the module
- Another opportunity to ask questions and debate/discuss with students & facilitators
- Quick **quiz** on lecture & reading material

Weekly Tasks & Final Project

Due Monday before Lecture:

- One page 2x spaced reflection:
  - Prompt given Monday post-lecture
    - Pass: Complete 7/10 Reflections
- Quizzes on reading & material
  - On bCourses, taken **during your discussion section**
  - Pass: Score ⅗ on at least 7 Quizzes

Final Project:

Goal:

Synthesize all 4 modules and think critically about current issues pertaining to stem cells.

** More details will be released as the deadline approaches. Typically a debate or presentation

Participation

Discussion Board:

You are required to post on discord and reply to at least one person who has previously posted, or contribute to the discussion. Alternatively, you can post and reply to one person's post on bCourses at least ¾ times, once for each module of the class. A prompt will be provided for each module, with some ideas for post topics provided.

Absences:

If you need to miss discussion, please email ronitnath@berkeley.edu

Admin Notes

- Discussions start **next week**! Attendance will be taken. Must attend 7/10 discussions.
- Remember to enroll in **both lecture and discussion** (different CCNs on CalCentral but you must enroll in both)
- If you have any questions throughout the semester (course content or administrative), please ask on the discord.
- We use stemcelldecal.com as our course website.
- Discord link →

Intro to Biology Module!

The central dogma of Biology

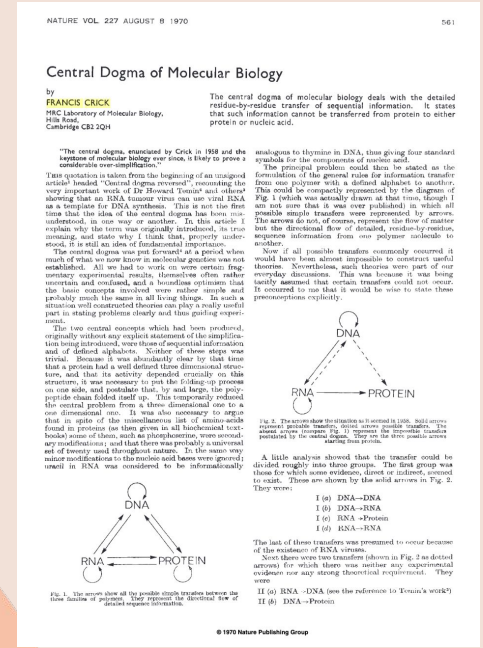
Central Dogma of Molecular Biology

by

FRANCIS CRICK

MRC Laboratory of Molecular Biology,
Hills Road,
Cambridge CB2 2QH

The central dogma of molecular biology deals with the detailed residue-by-residue transfer of sequential information. It states that such information cannot be transferred from protein to either protein or nucleic acid.



NATURE VOL. 227 AUGUST 8 1970

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The central dogma of molecular biology deals with the detailed residue-by-residue transfer of sequential information. It states that such information cannot be transferred from protein to either protein or nucleic acid.

"The central dogma, enunciated by Crick in 1958 and the keystone of molecular biology ever since, is likely to prove a considerable over-simplification."

This quotation is taken from the beginning of an unsigned article[1] headed "Central dogma reversed", recounting the very important work of Dr Howard Temin[2] and others[3] showing that an RNA tumour virus can use viral RNA as a template for DNA synthesis. This is not the first time that the idea of the central dogma has been misunderstood, in one way or another. In this article I explain why the term was originally introduced, its true meaning, and state why I think that, properly understood, it is still an idea of fundamental importance.

The central dogma was put forward[4] at a period when much of what we now know in molecular genetics was not established. All we had to work on were certain fragmentary experimental results, themselves often rather uncertain and confused, and a boundless optimism that the basic concepts involved were rather simple and probably much the same in all living things. In such a situation well constructed theories can play a really useful part in stating problems clearly and thus guiding experiment.

The two central concepts which had been produced, originally without any explicit statement of the simplification being introduced, were those of sequential information and of defined alphabets. Neither of these steps was trivial. Because it was abundantly clear by that time that a protein had a well defined three dimensional structure, and that its activity depended crucially on this structure, it was necessary to put the folding-up process on one side, and postulate that, by and large, the polypeptide chain folded itself up. This temporarily reduced the central problem from a three dimensional one to a one dimensional one. It was also necessary to argue that in spite of the miscellaneous list of amino-acids found in proteins (as then given in all biochemical textbooks) some of them, such as phosphoserine, were secondary modifications; and that there was probably a universal set of twenty used throughout nature. In the same way minor modifications to the nucleic acid bases were ignored; uracil in RNA was considered to be informationally analogous to thymine in DNA, thus giving four standard symbols for the components of nucleic acid.

The principal problem could then be stated as the formulation of the general rules for information transfer from one polymer with a defined alphabet to another. This could be compactly represented by the diagram of Fig. 1 (which was actually drawn at that time, though I am not sure that it was ever published) in which all possible simple transfers were represented by arrows. The arrows do not, of course, represent the flow of matter but the directional flow of detailed, residue-by-residue, sequence information from one polymer molecule to another.

Now if all possible transfers commonly occurred it would have been almost impossible to construct useful theories. Nevertheless, such theories were part of our everyday discussions. This was because it was being tacitly assumed that certain transfers could not occur. It occurred to me that it would be wise to state these preconceptions explicitly.

Fig. 1. The arrows show all the possible simple transfers between the three families of polymer. They represent the directional flow of detailed sequence information.

Fig. 2. The arrows show the situation as it seemed in 1958. Solid arrows represent probable transfers, dotted arrows possible transfers. The absent arrows (compare Fig. 1) represent the impossible transfers postulated by the central dogma. They are the three possible arrows starting from protein.

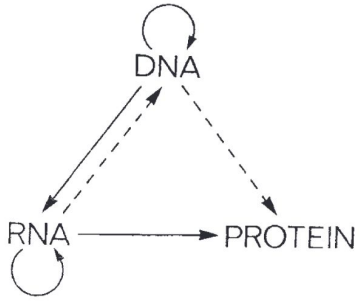
A little analysis showed that the transfer could be divided roughly into three groups. The first group was those for which some evidence, direct or indirect, seemed to exist. These are shown by the solid arrows in Fig. 2. They were:

I (*a*) DNA→DNA
I (*b*) DNA→RNA
I (*c*) RNA→Protein
I (*d*) RNA→RNA

The last of these transfers was presumed to occur because of the existence of RNA viruses.

Next there were two transfers (shown in Fig. 2 as dotted arrows) for which there was neither any experimental evidence nor any strong theoretical requirement. They were

II (*a*) RNA→DNA (see the reference to Temin's work[2])
II (*b*) DNA→Protein



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Central Dogma of Biology

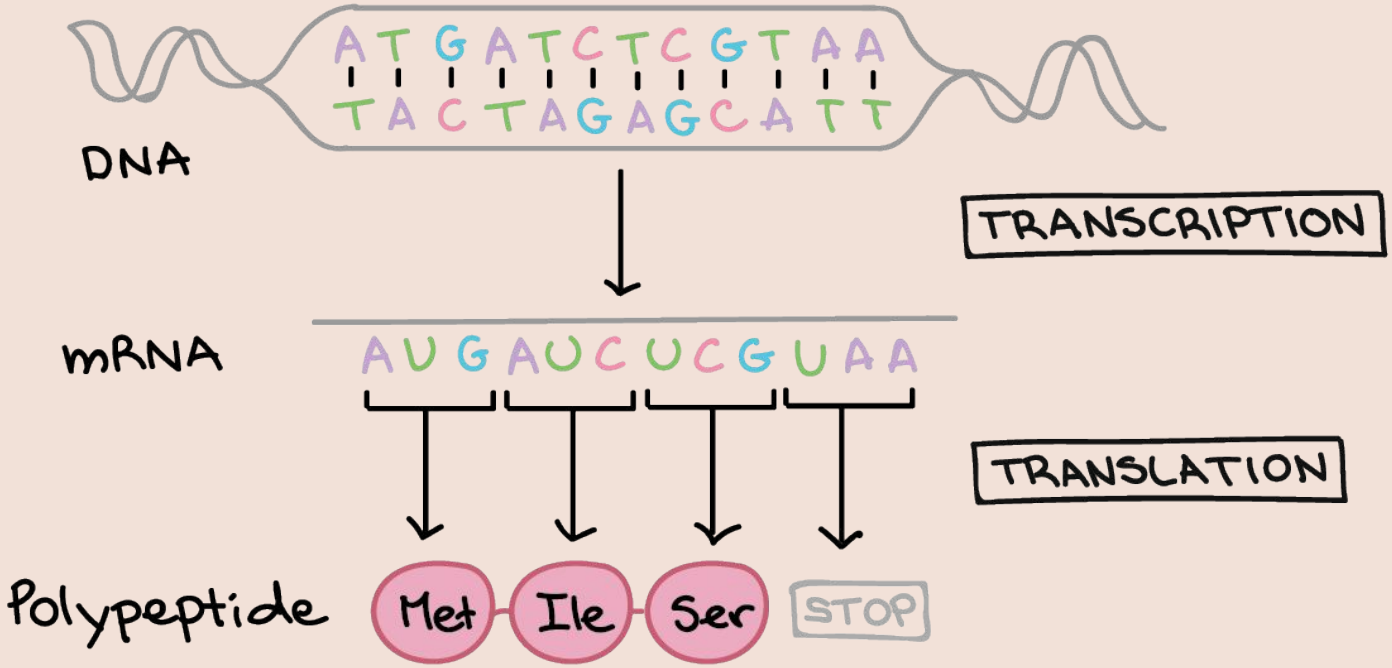
DNA → Transcription → **RNA** → Translation → **Protein**

- Our genetic material
- All somatic cells (except RBCs) contain the same genetic code, excluding blood cells
- Nucleotides
- Asexual and Sexual Reproduction

- RNA is copied from genes in a process called transcription.
- mRNA acts as the messenger between the genome and protein-producing ribosomes.
- Less stable than DNA

- Proteins are built from amino acids in a process called translation.
- “molecular machines”

THE CENTRAL DOGMA



Types of Cells in the Body


Stem Cells


Bone Cells


Blood Cells


Muscle Cells


Fat Cells


Skin Cells


Nerve Cells


Endothelial Cells


Sex Cells


Pancreatic Cells


Cancer Cells

If all of these kinds of cells have the same DNA, where is all of the variation coming from?

Gene expression & "transcriptomes"

- Not all coding DNA is actually active all the time
- The term transcriptome refers mRNA levels, a measure of which genes are being transcribed
- The transcriptome is often a better way of understanding what a cell is up to than just looking at the genome

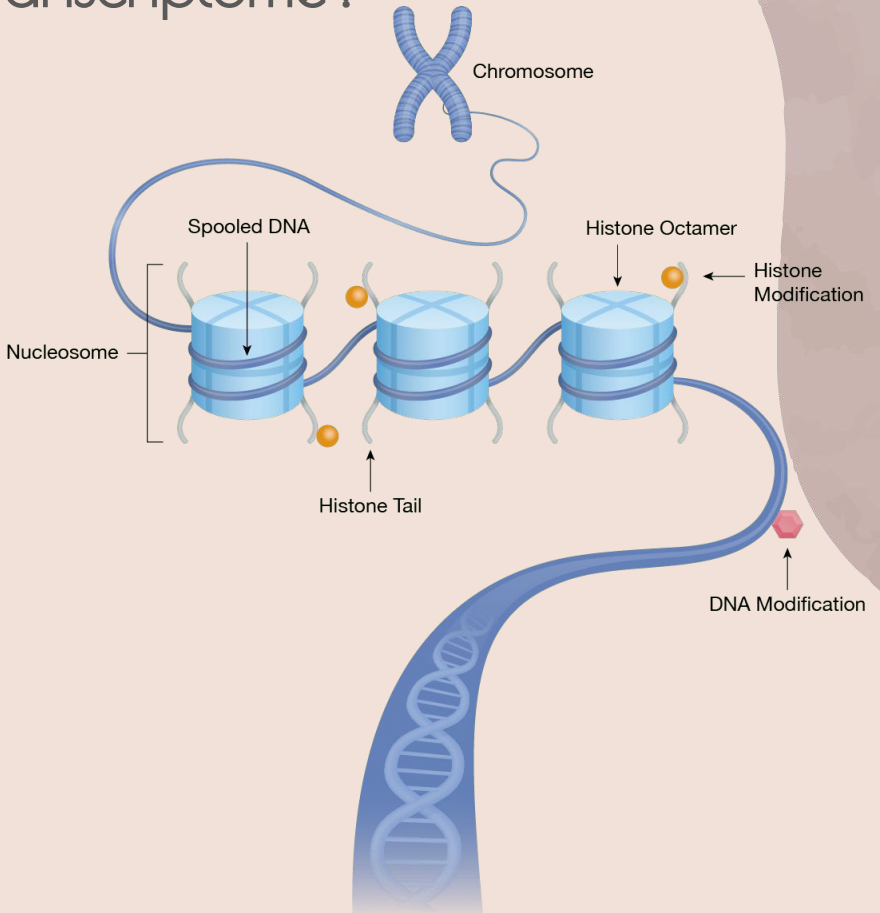
Our cells have the same **genome** but different **transcriptomes**

What influences the transcriptome?

- Epigenetic factors
  - Factors beyond sequence
    - Histone Tail modifications
    - DNA methylation (Methyl group added to DNA)
    - Tightness of chromatin winding

- Cells do not exist in a vacuum, they are influenced by (and influence) their microenvironment:

  - **Niche** - sum of all chemical & physical factors that can influence the cell



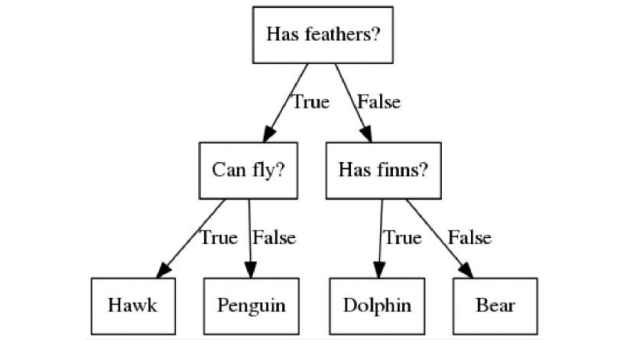
Stem Cell Properties

Potency

Potential to further specialize?

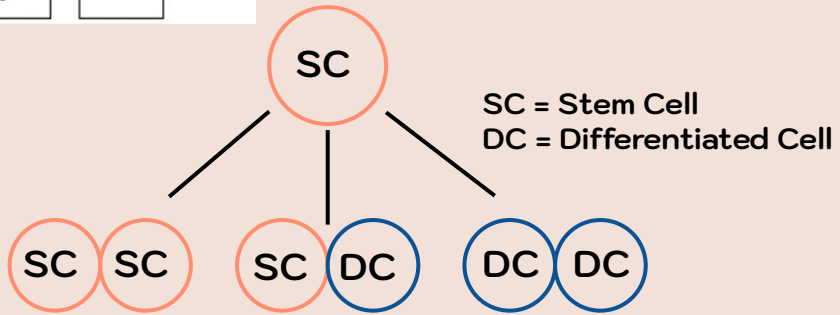
As you differentiate more, you become less potent

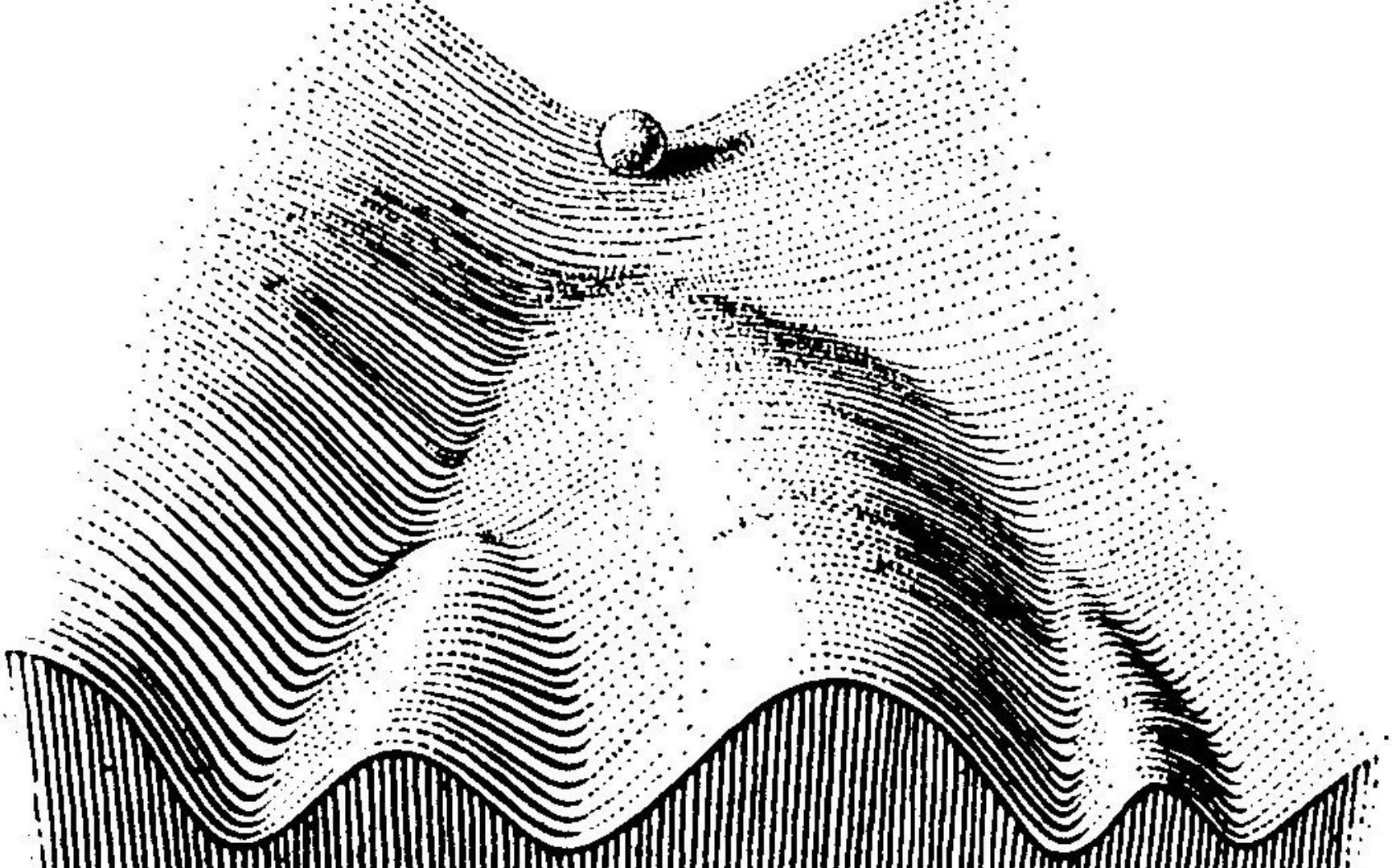
Tree diagram - iterative process

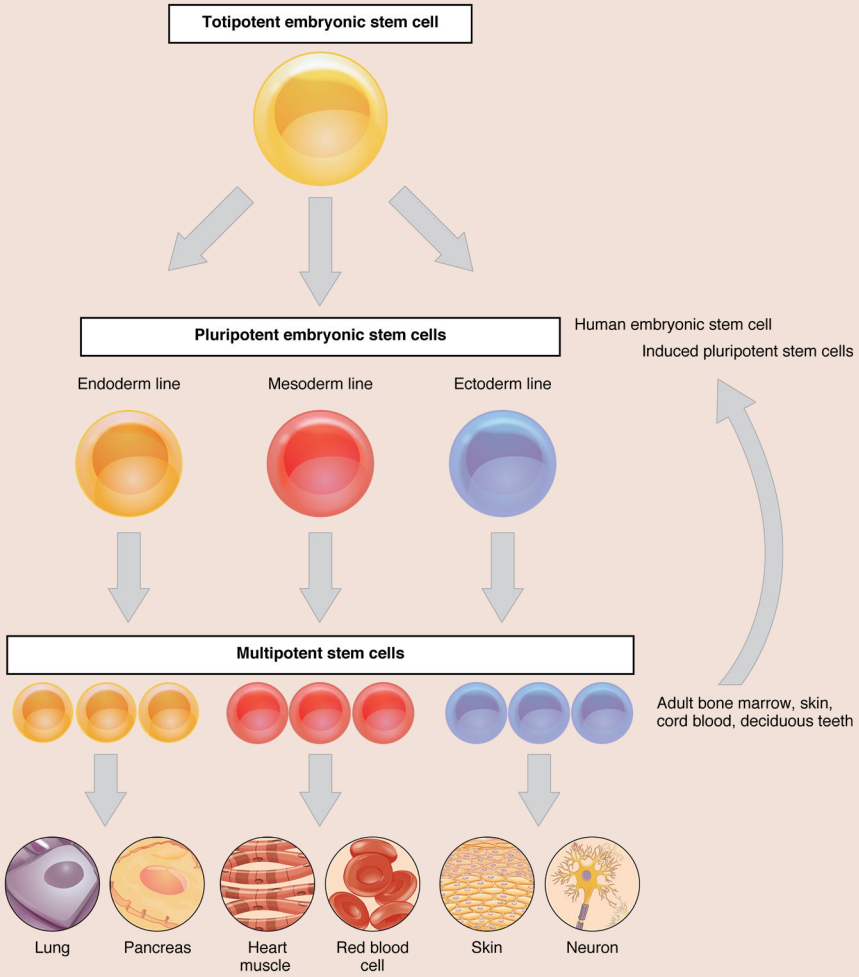


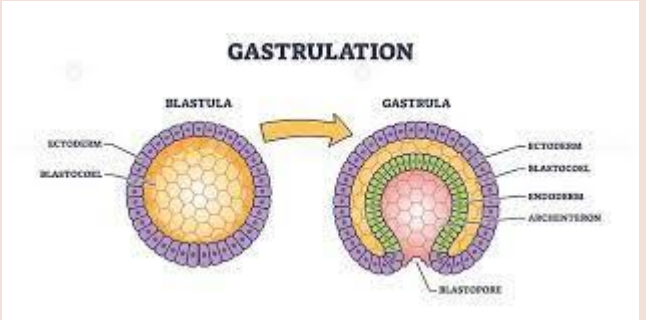
Self-Renewal

Ability to divide into more stem cells, rather than *only differentiating.*






Totipotent embryonic stem cell
Pluripotent embryonic stem cells
Human embryonic stem cell
Induced pluripotent stem cells
Endoderm line
Mesoderm line
Ectoderm line
Multipotent stem cells
Adult bone marrow, skin, cord blood, deciduous teeth
Lung
Pancreas
Heart muscle
Red blood cell
Skin
Neuron


GASTRULATION
BLASTULA
GASTRULA
ECTODERM
BLASTOCOEL
ECTODERM
BLASTOCOEL
ENDODERM
ARCHENTERON
BLASTOPORE

Additional Topics in Stem Cell Biology

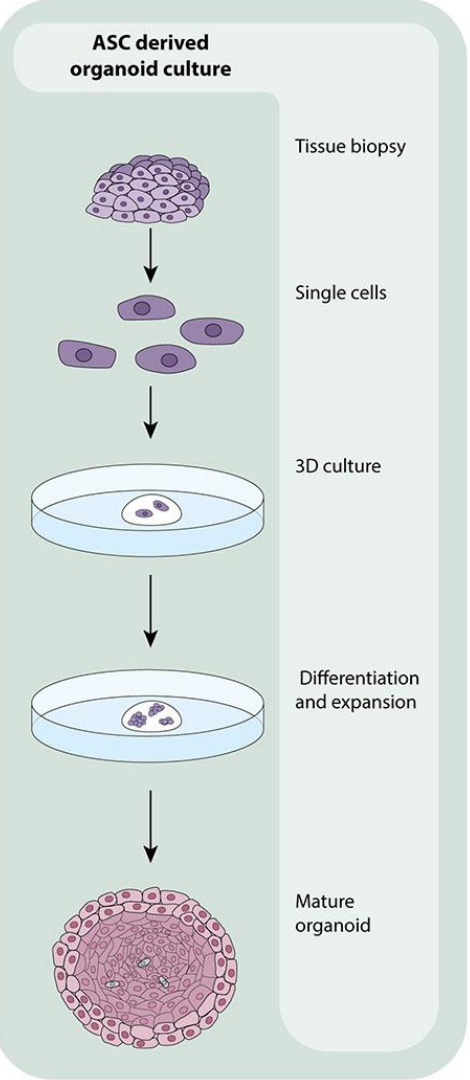
Two Main Paths in Biology (with lots of overlap!)

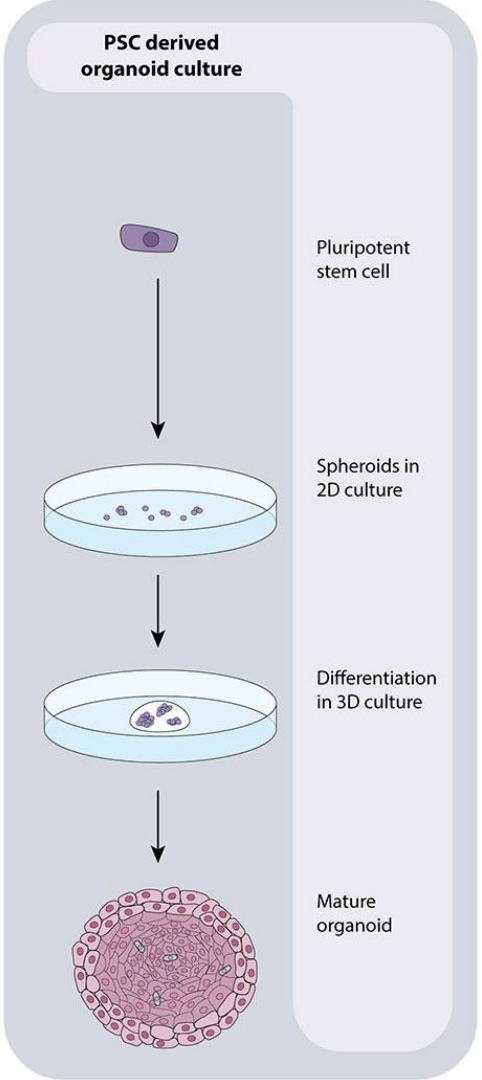
"Basic" Science

- What is "stem-ness"
- What's the molecular mechanism?
- What induces a certain tissue versus another?

Medical Science

- How can we use stem cells to revolutionize human medicine?
- How can stem cells improve drug development, cancer research, and regenerative medicine?





Using Stem Cells to Grow "Organoids"

Organoid: A mass of tissues that resembles an organ

Applications for medicine and translational science!

Reflections, Discussions, and Quizzes will start NEXT WEEK!
Optional readings on bCourses and #resources!

We'll see you next week for a guest lecture and discussions!