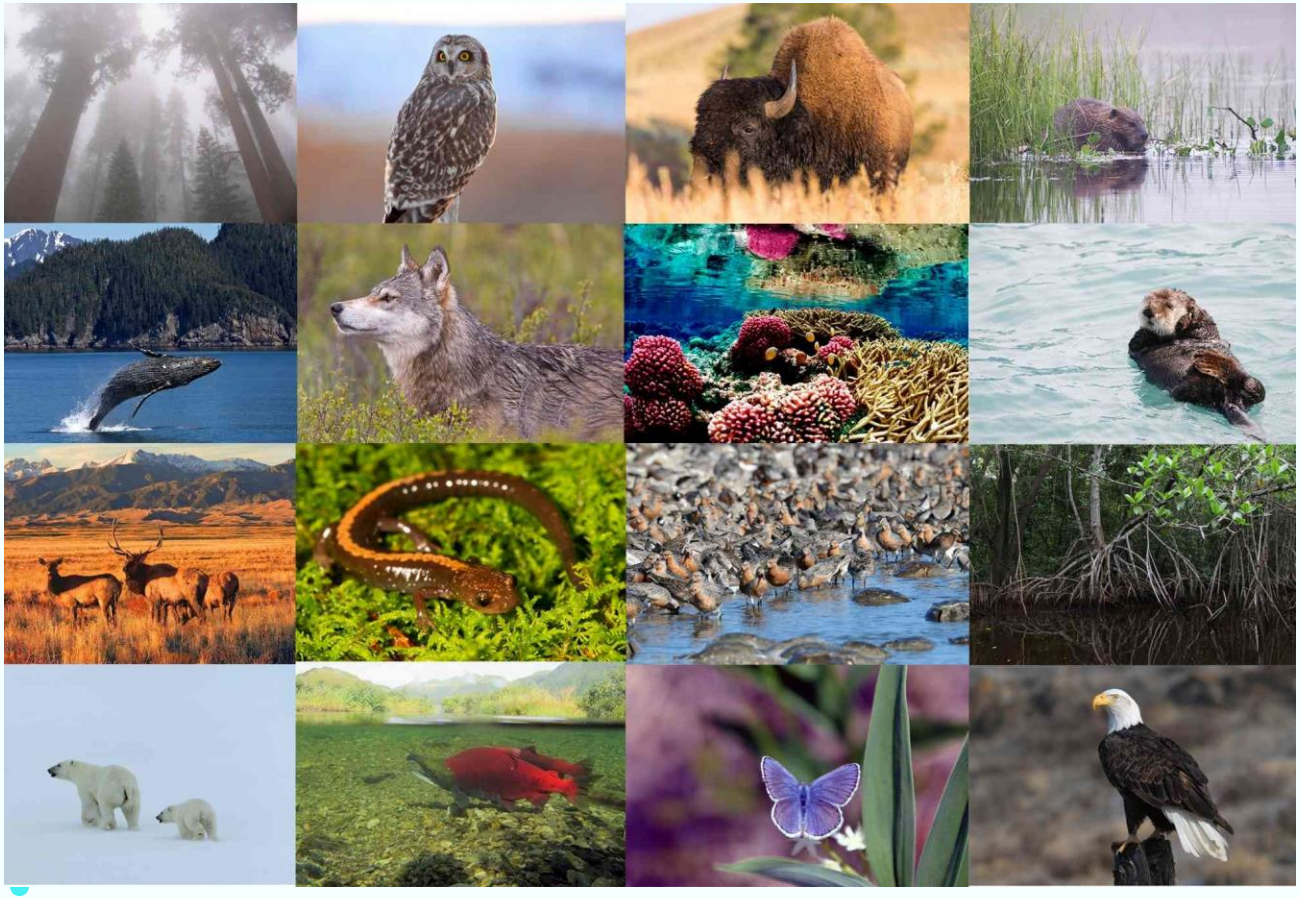
The Secret of Cellular Diversity

Introduction to Bioinformatics Course

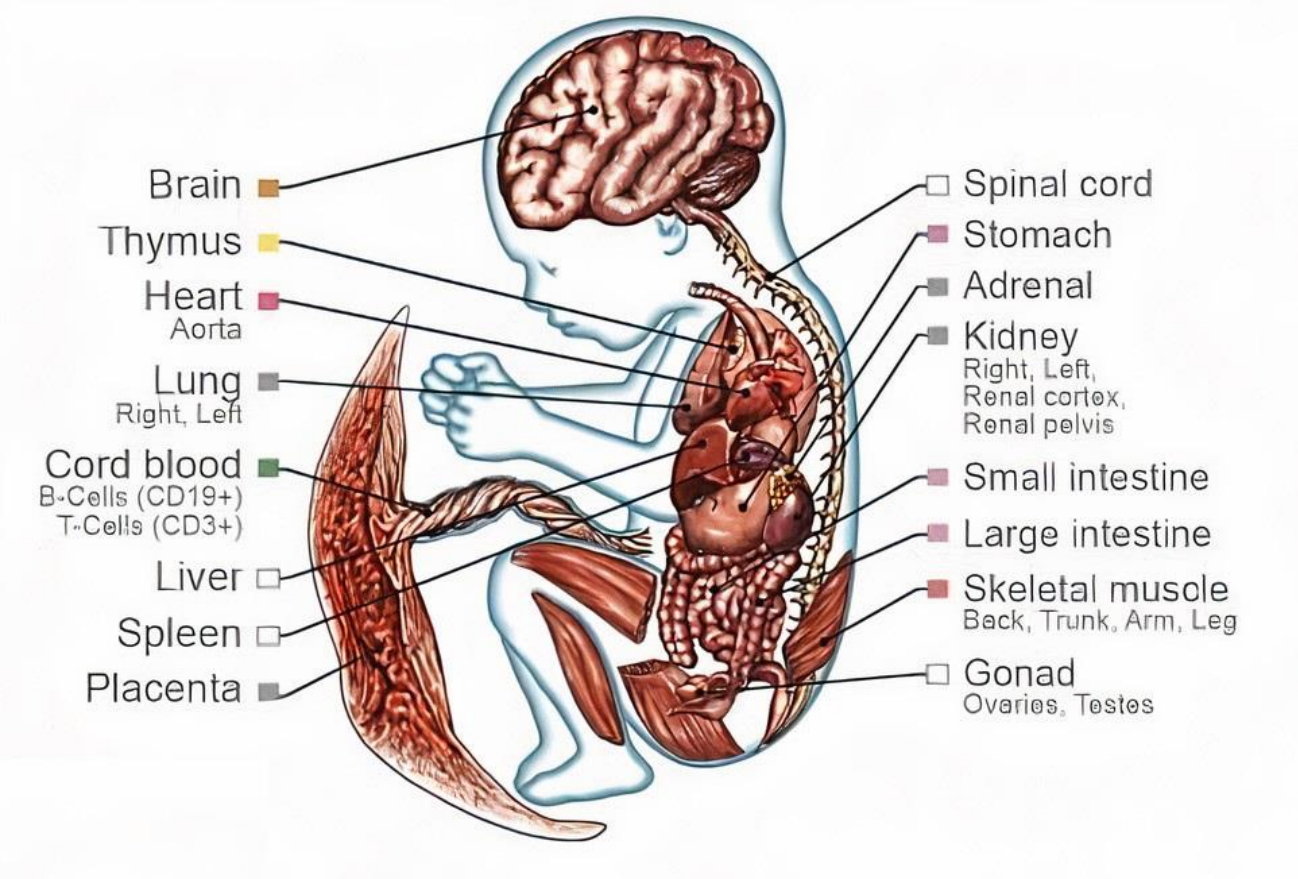
Niloufar Razani
Department of Computer Engineering
Sharif University of Technology

Fall 2023

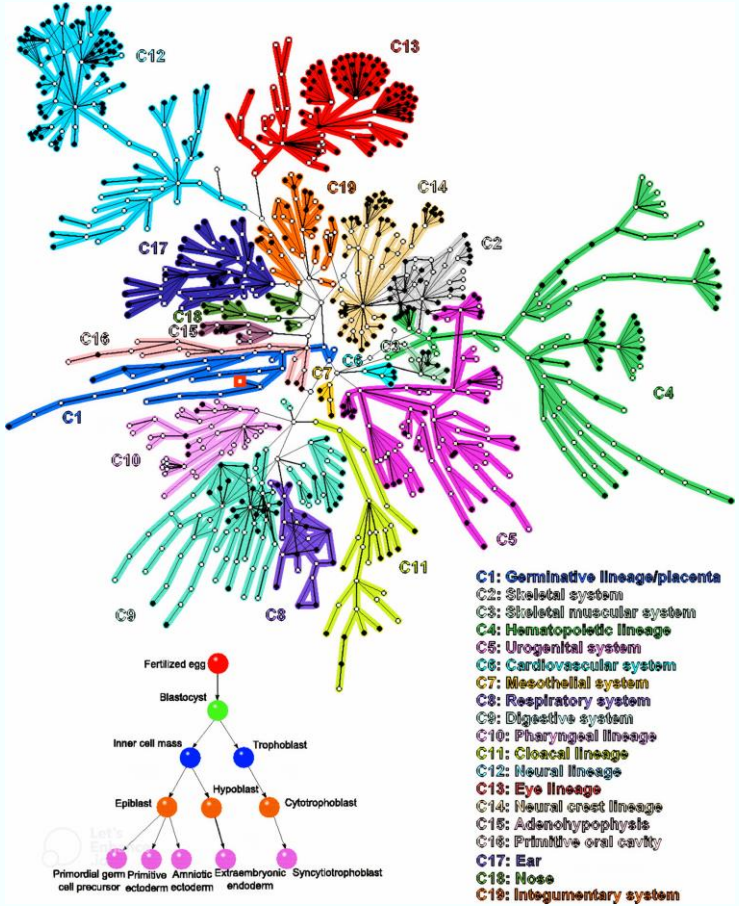
Biological Diversity



Cellular Diversity in Human Body

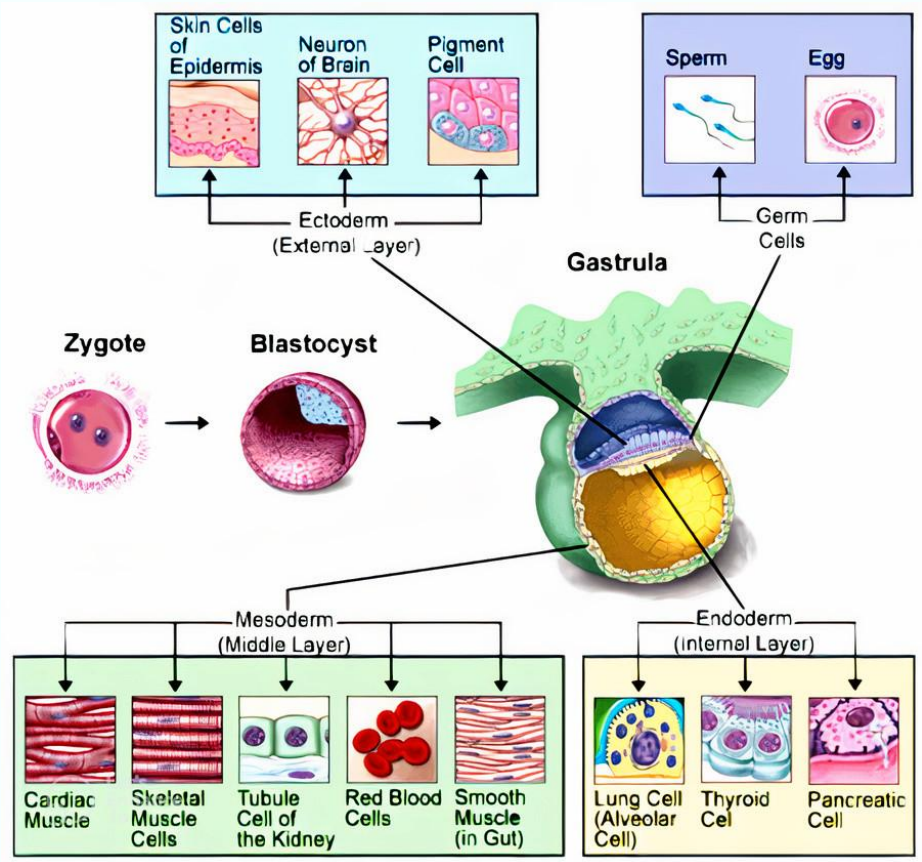


Differentiation Network of Human Cells



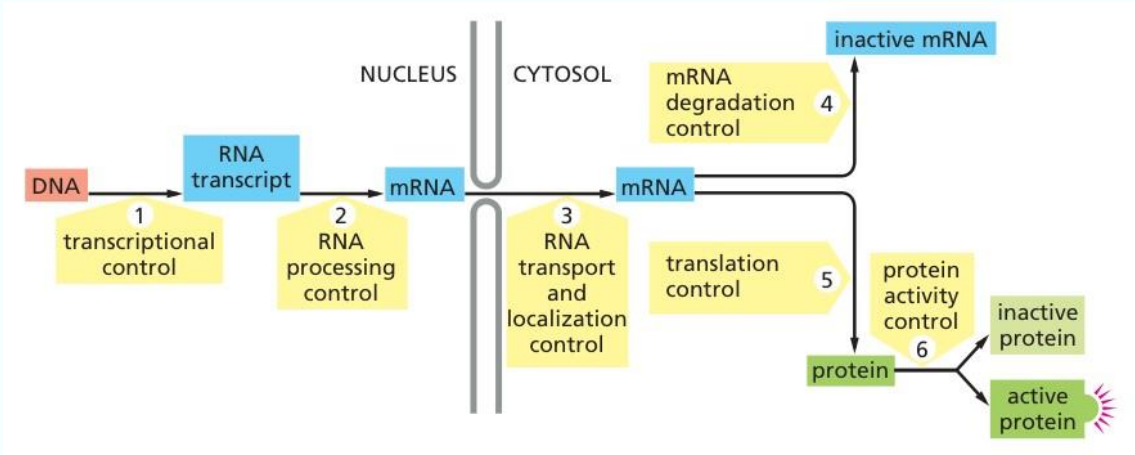
Human Cells Development

- A human zygote can give rise to all the cell types of the human body.
- This ability makes the zygote **totipotent**.
- after multiple rounds of cell division, the cells of the embryo become more restricted in their potential **(pluripotent).**
- Eventually, the cells of the embryo are split into three different groups known as germ layers: **Mesoderm, Endoderm,** and **Ectoderm.**
- Each germ layer will, under normal conditions, give rise to its own specific set of tissues and organs.



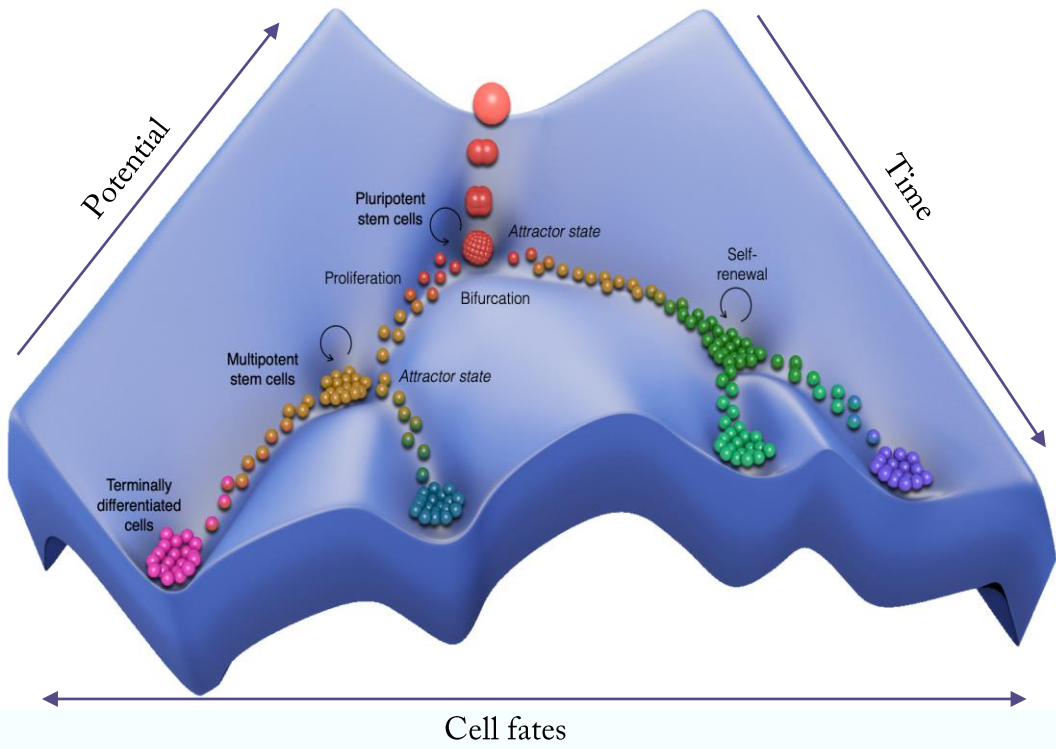
Control of Gene Expression

- Even the simplest single-celled bacterium can use its genes selectively. And, in multicellular plants and animals, gene expression is under even more elaborate control.
- Cells make and accumulate different sets of RNA and protein molecules: that is, they express different genes.
- There are many steps in the pathway leading from DNA to protein, and all of them can in principle be regulated.
- For most genes, however, the control of transcription is paramount. This makes sense because only transcriptional control can ensure that no unnecessary intermediates are synthesized.

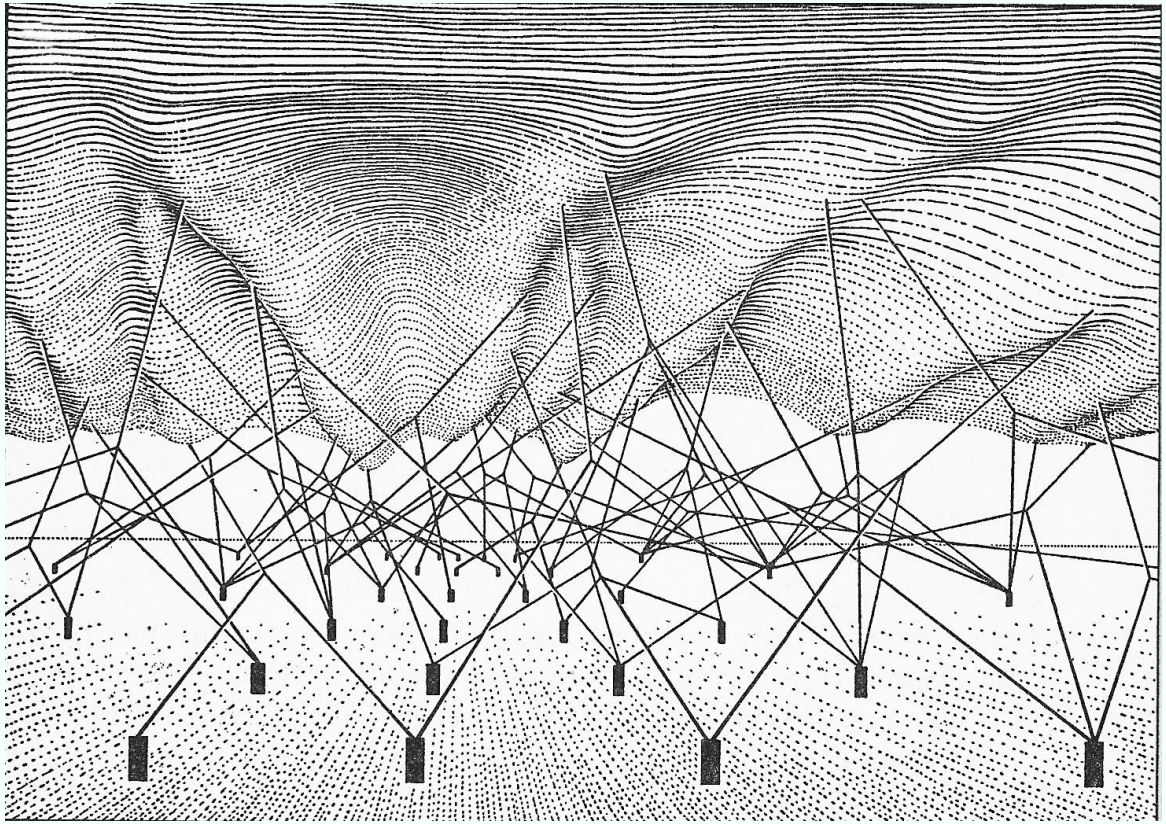


Waddington Epigenetic Landscape

- A metaphor for how gene regulation modulates development.
- The marbles will sample the grooves on the slope, and come to rest at the lowest points.
- These points represent the eventual cell fates, that is, tissue types.

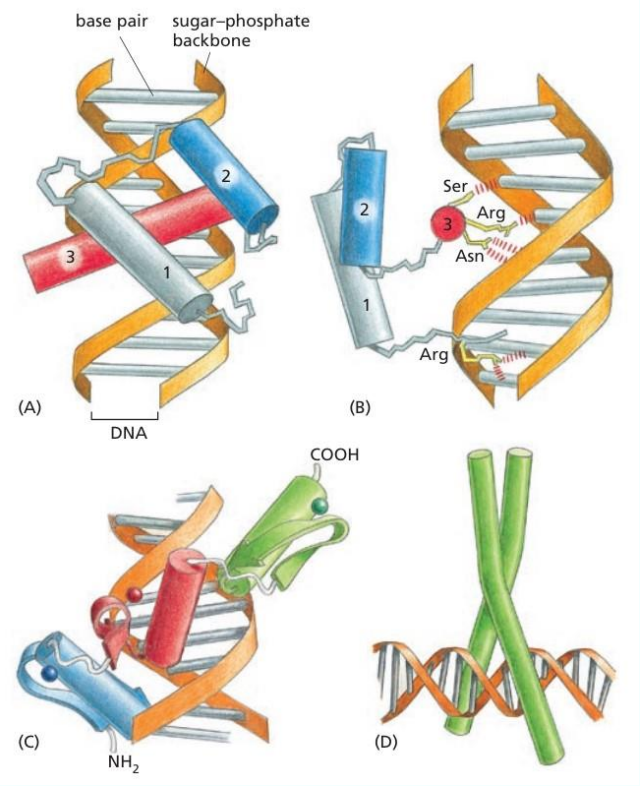


The Landscape Backstage

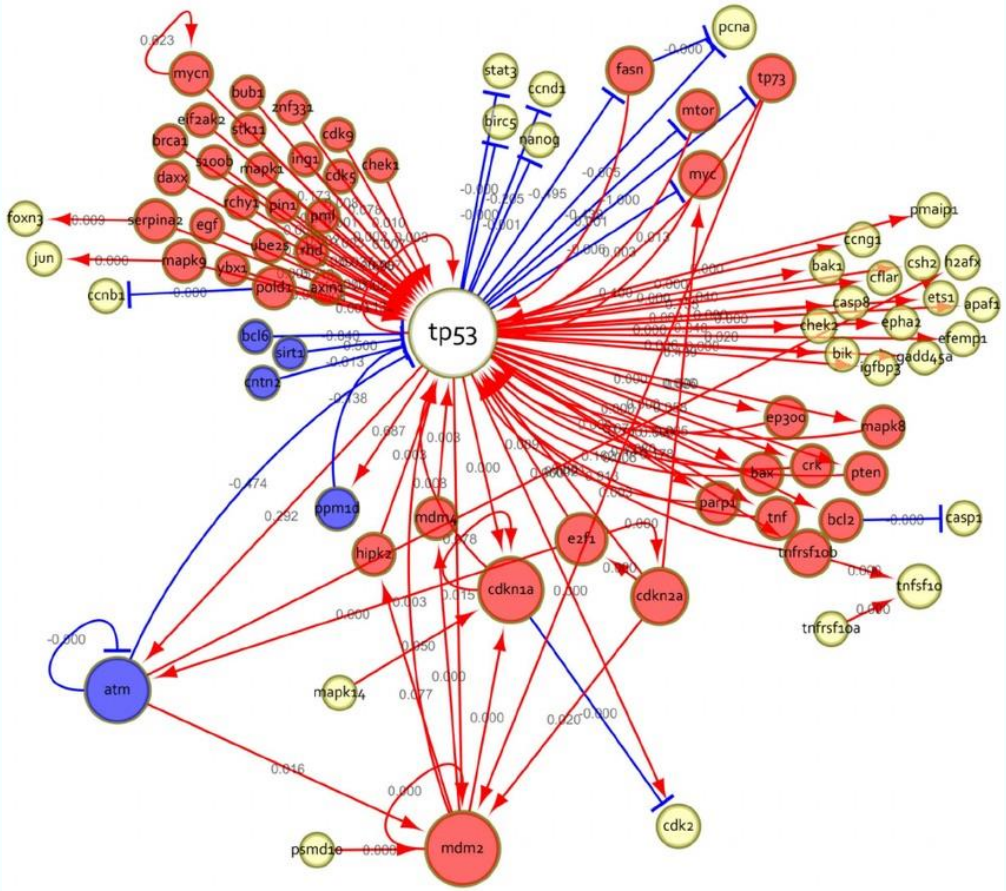


How do Genes Interact?

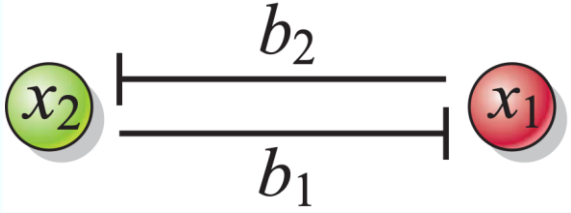
- In addition to the promoter, nearly all genes, whether bacterial or eukaryotic, have **Regulatory DNA Sequences** that are used to **switch the gene on or off**.
- These sequences do not work by themselves. To have any effect, they must be recognized by proteins called **Transcription Regulators**, which bind to the DNA.
- Proteins that recognize a specific DNA sequence do so because the surface of the protein fits tightly against the special surface features of the double helix in that region.

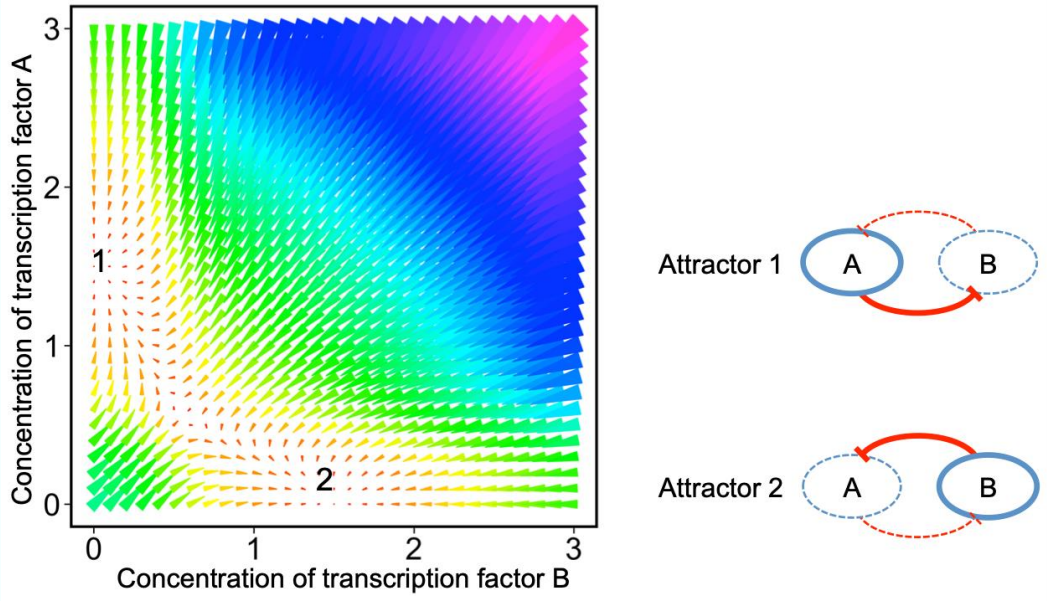


Gene Regulatory Network



Bistable Switches





RESOURCES

- Alberts, Bruce, et al. *Essential cell biology*, Chapter 8, Control of Gene Expression.