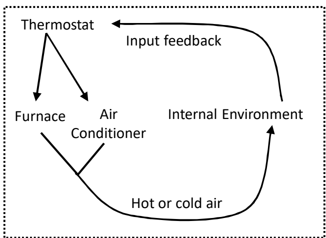
Homeostasis

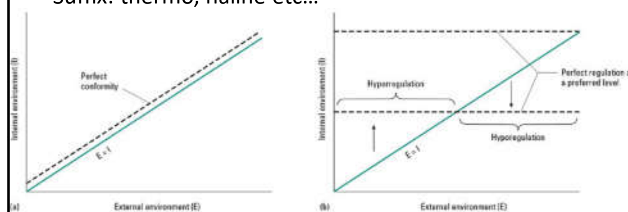
- Regulation of internal body conditions
- Often regulated via negative feedback system



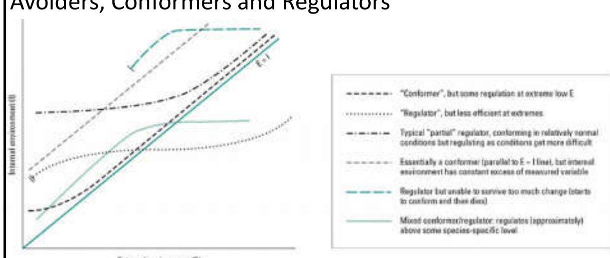
External Environment

External vs. Internal conditions

- Three general types of managing internal conditions
  - **Avoiders**
  - **Conformers**
  - **Regulators**
- Prefix: **Homeo** or **poikilo**
- Suffix: thermo, haline etc…

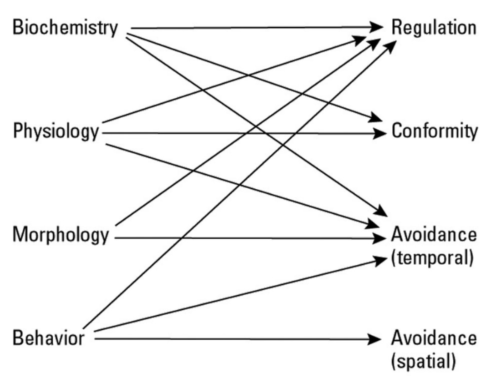


Avoiders, Conformers and Regulators



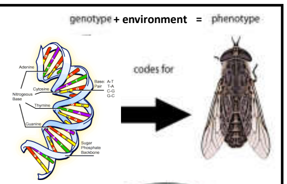
Icefish:
Stenothermal or eurythermal?
Oligothermal or polythermal?
Homeothermic or poikilothermic?
Ectothermic or endothermic?
Avoider, conformer or regulator?

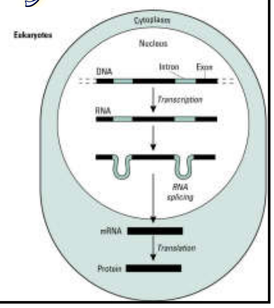
Various methods for regulating, conforming or avoiding



Mechanisms of Adaptation

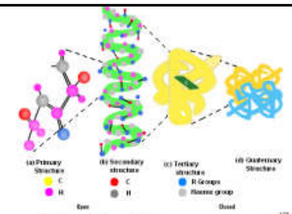
- **DNA** – genotype
- **Phenotype** – what selection acts on.
- Review basics of **protein synthesis.**
- Genes are expressed to produce proteins. Proteins perform most functions, make up what the phenotype is.

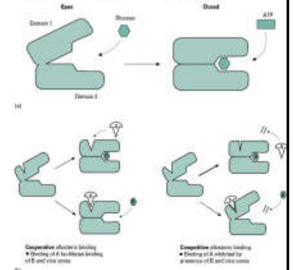




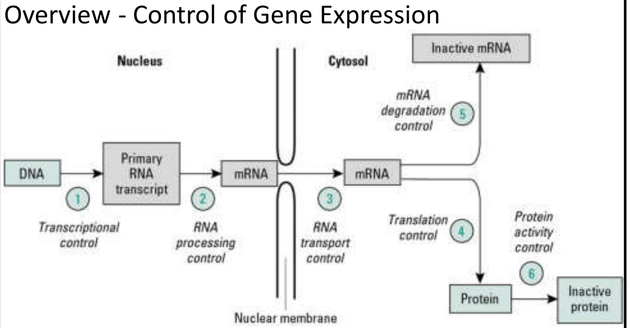
Proteins

- Protein diversity
  - Number proteins= 20^n (n=# AA)
  - Sequence of 10 AA -> ~10 trillion different proteins
- Structure and shape of proteins
- **Ligand**
- **Allosteric effect**
- Protein actions
  - Pump
  - Motor
  - Enzyme
  - Etc…

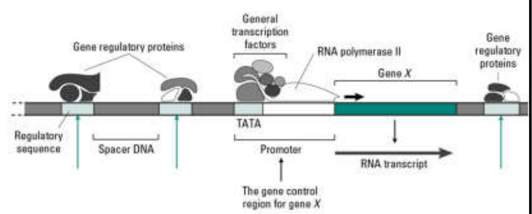




Overview - Control of Gene Expression

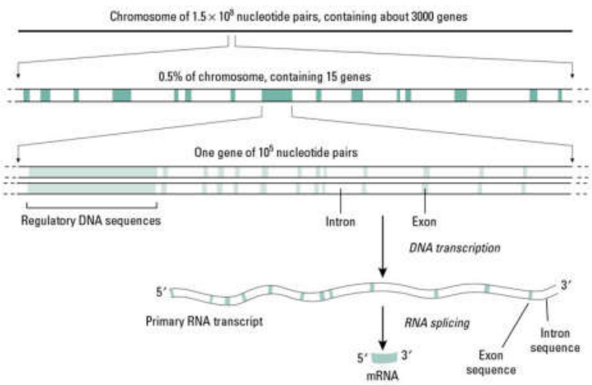


Gene Regulation



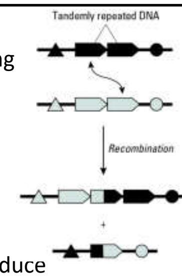
- Gene regulatory proteins (activators and repressors)
- Promoter region and transcription factors

RNA Processing

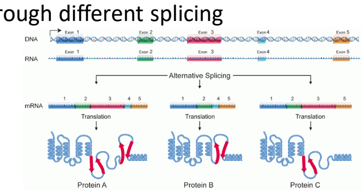


Protein Evolution

- **Point mutations** -> fine tuning of existing proteins
- Duplications
  - **Pseudogenes**
  - **Gene families**

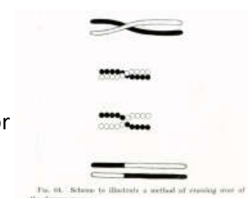


- **Intron-exon system** – one gene can produce multiple proteins through different splicing (alternative splicing)

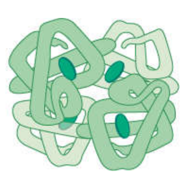


Protein Evolution

- **Recombination**
  - Homologous (crossing over) or non-homologous

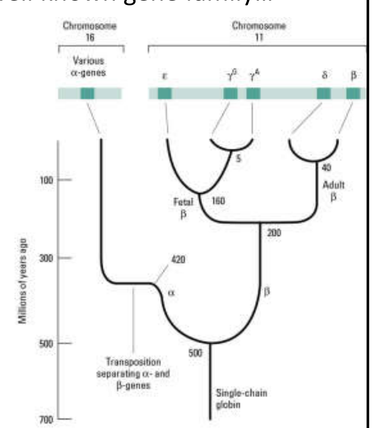


- **Protein complexes**
  - Form of quaternary structure



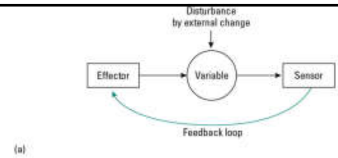
Hemoglobin is also a well known gene family…

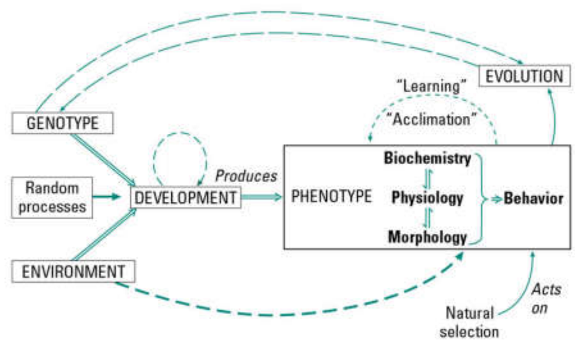
- Multiple forms:
  - Maternal vs. fetal forms
  - Can evolve independently
- Expected to be under strong selection



Feedback loops

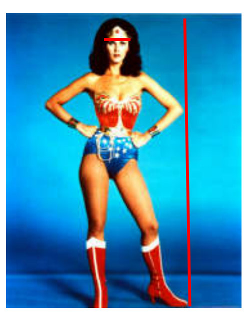
- Key course concepts:
  - Homeostasis
  - Energetics
  - Optima





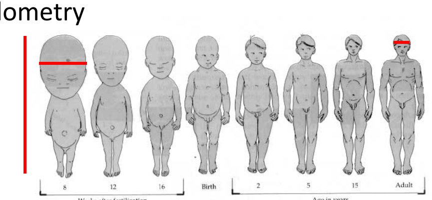
Allometry

Head width ~ 13% of height

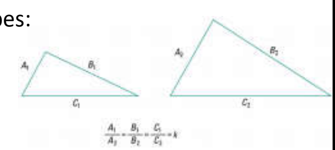


Head width ~ 9% of height

Allometry



- "The structural and functional consequences of changes in size or scale among otherwise similar organisms" – Schmidt-Nielsen
- Isometric geometric shapes:

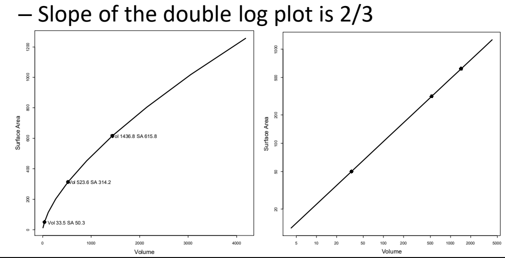


Allometry

- Anything that does not change isometrically, changes allometrically
  - **Isometry**, **negative** and **positive allometry**
- Why it matters:
  - Organisms vary in size over 21 magnitudes
    - Bacteria – 10^{-13} grams
    - Blue whale – 10^{8} grams
  - Very basic functionality (exchange with the environment) works differently at those scales

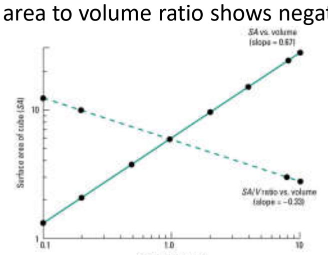
Allometry

- For a sphere (by definition, an isometric shape)
  - Surface Area = $4\pi r^2$
  - Volume = $4/3\pi r^3$
  - As length increases, volume increases at greater rate than total surface area
  - Slope of the double log plot is 2/3



Allometry of surface area

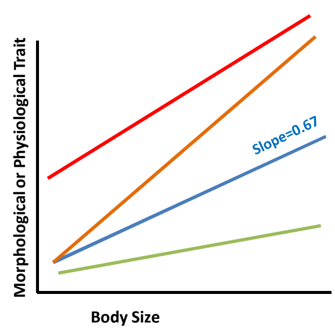
- Surface area to volume ratio shows negative allometry

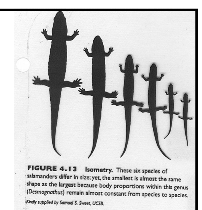


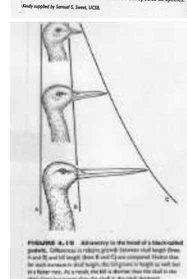
- Cellular level – physiological constraint on cell size
- Organism level - the rate of exchange with the environment changes dramatically with size.

Allometry

- Relationships can be easily described mathematically
- Comparing lines tells us a lot about species

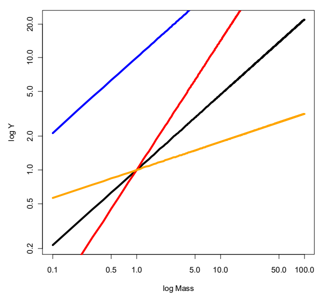






Allometry

- Most of the time we will examine allometry in terms of body size
- Power function:
  - **$Y = a\,M^b$**
    - Y = trait of interest
    - **a** = proportionality constant
    - **b** = slope
    - **M** = mass
  - a=1.0 b=0.67
  - a=10 b=0.67
  - a=1.0 b=1.15
  - a=1.0 b=0.25
- Not always linear
- Log form of equation
  - Log Y = log a + b log M



Example allometric relationships

- The proportionality constant and mass exponent describe allometric relationships.
- b – how something changes with size
  - No relationship to size (technically, negative), b=0
    - Hemoglobin concentration, cell size
  - If something is isometric, b=1.0
    - Eg. blood or lung volume in mammals
  - Positive allometry (b>1) – mammal bone thickness b= 1.08
    - Why? What does this mean biologically?
  - Negative allometry (b<1) – human skull size, mammal heart rate
- a – how the intercept changes among lines