Genetics: The Information Broker
27 November 2007

- Introduction
- Genetics of inheritance – Mendelian genetics (≥1860)
- Genetics of cell’s operation – Molecular genetics (≥1950)
- Genetics “on the cutting edge” (≥2000)

Genetics of Inheritance

- Classical or Mendelian genetics (Gregory Mendel)
- Competing hypotheses
  - Blended inheritance
  - Particulate inheritance
- Testing the hypotheses
  - Flower color in peas (1 parent with red flowers and 2nd parent with white flowers)
  - Results: two classes of flowers
    - Red (300 seedlings)
    - White (100 seedlings)
- Conclusion:
  - Support for particulate theory; reject blended theory
  - Specific quantitative data: 3:1 ratio

iClicker Question

- If you were to cross rabbits that were black with rabbits that were white and the offspring were either white or black, this outcome would support the theory of ___________.
  - A. particulate inheritance
  - B. conspicuous inheritance
  - C. Lamarckian inheritance
  - D. blended inheritance
  - E. none of the above

The studies of Gregor Mendel in the mid 1860’s provide data in support of the theory of particulate theory of inheritance. The other notable observation of Mendel was the quantitative data showing a ratio of _____ in the offspring of pea plant flower color.
  - A. blended
  - B. 3:1
  - C. 1:1
  - D. 50:50
  - E. 1:4.632

Mendelian Genetics (1860’s)

- Gene – trait determined by a sequence of DNA
- Allele - alternative versions of the same gene (e.g., normal hemoglobin versus sickle cell hemoglobin)
- Dominant allele (e.g., red flower color; brown eyes)
- Recessive allele (e.g., white flower color; blue eyes)
- Chromosomes – physical packaging of genes in nucleus
- Pairs of chromosomes (homologous pair)
- Genome – all of the genes of an organism in the nucleus

For most traits, you carry two copies of the same gene, one on each chromosome pair. These copies are called _____.
  - A. chromosomes
  - B. alleles
  - C. dominant gene
  - D. recessive gene
  - E. none of the above
The genome of any organism is packaged as elongate structures called chromosomes that reside in the _____.

A. chromatin  
B. Golgi body  
C. endoplasmic reticulum  
D. ribosome  
E. nucleus

Some traits more common in one sex; genes coding for these are on the 21st pair of chromosomes

Examples
- Color blindness: males
- Baldness: males
- Hemophilia: males
Human Genome and Genetic Differences

The Complexity of the Genome

- 30,000 to 40,000 genes
- Only ~1.6% encodes genes
- Millions of differences between any two people

iClicker Question

The number of chromosomes in any cell of your body (except for gametes) is _____.
- A. 16
- B. 32
- C. 41
- D. 46
- E. None of the above

Molecular Genetics

- Structure of DNA and RNA – information storage, transmission and expression
- Replication of the information – copying/duplication
- Transcription of the information – transcribing
- Translation of the information – expressing as proteins

iClicker Question

In genetic crosses, the re-current quantitative ratio of 3:1 among offspring supports the presence of ____ copy/copies of each gene in an organism.
- A. four
- B. three
- C. two
- D. one

Molecular Genetics

Information Processing in the Cell

The number of genes in any cell of your body (excluding eggs and/or sperm) is between _____.
- A. 1,000 – 3,000
- B. 5,000 – 10,000
- C. 30,000 – 40,000
- D. 40,000 – 50,000
- E. None of the above
In the following figure, the information process linking the DNA to RNA (see white arrow) is called _______.

A. replication
B. transcription
C. translation
D. gene splicing

DNA – Deoxyribonucleic acid (nucleus)
RNA – Ribonucleic acid (protoplasm)
Monomer – nucleotides (N=5)
- Guanine (always binds to Cytosine - G:C)
- Adenine (always binds to Thymine - A:T)
- Cytosine (always binds to Guanine - C:G)
- Thymine (always binds to Adenine - A:T)
- Uracil (T replacement in RNA)
Polymer – polynucleotide (DNA & RNA)

DNA Polynucleotide: One Strand

Sequence of Nucleotides and Genes

- Linear sequences of nucleotides
- Gene: sequence of nucleotides responsible for a specific traits (e.g., eye color; hemoglobin and sickle cell anemia)
Molecular Genetics: A Single Gene

- Exact sequence of nucleotides is important

ATTAGCGGTA TGGGTTAAGATCC

- Any change in sequence changes the information ("RAT to CAT") and constitutes a mutation

ATTAGCGGTA CGGGTTAAGATCC

Molecular Genetics: Replication

- Replication: process of duplicating DNA to produce a new and exact copy with fidelity
- includes "spell checking"

Molecular Genetics: Transcription

- Process whereby information in DNA is "transcribed" into another type of message called mRNA (message RNA)
- mRNA made in nucleus and subsequently shuttled to protoplasm
- In protoplasm, mRNA finds its way to the ribosome (where protein synthesis occurs)

Compartmentation: Ribosome

iClicker Question

In a DNA polynucleotide, the base sequence is T-AAA-G-C-T. Which base sequence would be bonded to this section of a complementary strand of DNA polynucleotide?

A. A-C-G-T-A-A
B. A-C-G-U-U-A
C. A-G-C-T-T-A
E. A-T-T-C-G-A

iClicker Question

An mRNA sequence is 300 nucleotides in length. The number of amino acids in the protein translated from this mRNA is _________.

A. 50
B. 100
C. 150
D. 200
E. 600
**Molecular Genetics: Translation**
- Process whereby information in mRNA is “transcribed” into proteins (polypeptides)
- Monomer: amino acids (e.g., lab exercise)
- Location: ribosome for protein synthesis
- **Genetic code**: specificity and fidelity
  - Three consecutive nucleotides of mRNA used to “call in” unique amino acid

**Translation and the Genetic Code**

**Genetic Code and Evolution**
- **Fidelity** in copying information
- **Specificity** in information
- Expression of gene for manufacturing of polypeptide leading to protein (e.g., enzyme)
- **Genetic Code** is conserved in evolution – all organisms use the exact same coding process
- Example of Genetic Code: laboratory exercise using hemoglobin across multiple species

**Genetics: The Information Broker**
- **Introduction**
  - Criticality of having an “information broker”
- Genetics of inheritance – Mendelian genetics (>1860)
- Genetics of cell’s operation – Molecular genetics (>1950)
- Genetics “on the cutting edge” (>2000)

**Genetics “on the Cutting Edge”**
- Genetic Counseling (probability of offspring with particular traits)
- Forensic Sciences (e.g., CSI TV series)
- Genetic Engineering (e.g., “starlight” strain of corn)
  - GMO’s (Genetically Modified Organisms)
- Genetic “Sleuthing”
  - Human applications (e.g., ice man in the Alps > 5,000 years)
- Pharmaceuticals
  - Toxicology of drugs and chemicals (e.g., Celebrex)
Chapter 26

- Exclude the following:
  - Page 651: Mendel’s Laws of Heredity
  - Page 652: Steps in Solving Heredity Problems
  - Pages 654 - 656: Codominance through Pleiotropy

Take-Home Messages

- Inheritance of traits is best explained by the hypothesis that traits are not blended but expressed as distinct units called genes and alleles; this is the particulate theory of inheritance.
- The following two sequences underpin all of molecular genetics:
  - DNA → mRNA → Polypeptide → Protein
  - DNA → DNA
- Genetic code is a process common to all organisms and is prima facie evidence for evolution.
- Application of molecular techniques is substantial and will affect dramatically your lives and that of your children.