Biology 225, important websites

My faculty website:
http://faculty.orangecoastcollege.edu/grussell

Mastering A&P:
http://www.masteringaandp.com

Blackboard
http://occ.blackboard.com

(lecture notes, course packet, assignment instructions, etc.)

(weekly assignments and quizzes)

(grades for lecture tests and lab assignments will be posted here)
Biology 225, tips for success

Before class:

Read ahead. At least look at the pictures in the book. It’s OK if you don’t understand it all; that’s what I’m here to help you with.

In class:

Take notes. Yes, I am giving you Powerpoint slides to help guide you. Sometimes you will get a lot of them, other times, not as many. But, you should always be writing as many notes as possible.

After class:

(This is important!) Rewrite your notes using my Powerpoint slides, the notes you took, and your book. Once you’ve spent time doing this, then start quizzing yourself as much as it takes to fully understand the material.
Typical Forgetting Curve for Newly Learned Information

Retention

First Learned

Reviewed

Days

0 1 2 3 4 5 6 7

60% 70% 80% 90% 100%

Hermann Ebbinghaus
Biology 225, more tips for success

Move past speed bumps:
Ask questions, come to my office hours, do what it takes to get over any misunderstanding you have. If you’re confused now, chances are it will only get worse. I can’t read your mind...if you don’t tell me there’s a problem, I don’t know one exists.

Come to class:
Duh!

You’re not alone:
Find someone to study with. Not only that, find the right person to study with. It’s invaluable. If you don’t know anyone in the class, I’ll be happy to introduce you to someone. Think of me as an academic matchmaker.
Biology 225, assorted thoughts

Yes, this class is hard:
You will work very hard in here, and the second half of the semester especially will feel very busy; I promise you that if you take time now to work ahead, it will benefit you later.

I have high expectations:
I am willing to help you, but it is ultimately your responsibility to be prepared for class, assignments, and exams.

Yes, I give you the notes:
But I don’t spoon feed you information. You still need to do work outside of class to understand concepts, and to learn to think critically about the topics we discuss.
Exam make-up day

This is important.

If you miss an exam, the only time you can make it up is Friday, May 16, 2014 at 10am.

Your absence from an exam must be legitimate: illness (with doctor’s note), car accident, college-recognized event, etc. No birthday parties at Disneyland, Hawaii vacations, etc.
Germ layer formation begins with the first cell division in the newly fertilized zygote -- on its way to becoming a multicellular embryo.

Through *cell movements*, blastula becomes a hollow sphere.
Next stage is an **invagination** of the hollow blastula, called **gastrulation**.

This process makes a **diploblastic** embryo as it forms the first two germ layers:

- **Ectoderm** (on the outside)
- **Endoderm** (on the inside)
In most (but not all) animals, the diploblastic embryo adds a third primary germ layer called **mesoderm**, becoming **triploblastic**.

**Mesoderm** forms between ectoderm and endoderm, and arises by a process called **Enterocoely**:

**Enterocoely** (mesoderm arises from **endoderm**) -- **Deuterostomes**

![Diagram of blastopore and archenteron](image)
Developmental patterns

The three primary germ layers go on to form all the other cell types and tissues in the animal. This is what happens in triploblastic animals:

- **Ectoderm:** Skin and nervous system
- **Endoderm:** Gut and associated organs and structures
- **Mesoderm:** Muscles, gonads, internal skeletons
Development requires increasing **differentiation**, from *totipotent* stem cells (can become any cell type) to full specialized cells with fixed fates.

**Example:** differentiation of muscle

- **Zygote:** source of all cells
- **Early cell division:** can become any cell type
- **Early mesoderm:** muscle, bone, gonads
- **Muscle stem cells:** any muscle type
- **Skeletal muscle:** fate fixed

**Totipotent** → **Fully differentiated** → Time
Understanding Development

The details of development are incredibly complex, and are beyond the scope of this class.

However, a basic understanding can be gained from two principles:

Knowledge of the four groups of macromolecules

The fact that all of this (all of who we are) is a result of genes being turned on or turned off at critical time points
Functional groups are common on macromolecules

<table>
<thead>
<tr>
<th></th>
<th>SHORTHAND</th>
<th>BOND STRUCTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carboxyl (acid)</td>
<td>—COOH</td>
<td>—C—O—H</td>
</tr>
<tr>
<td>Hydroxyl</td>
<td>—OH</td>
<td>—O—H</td>
</tr>
<tr>
<td>Amino</td>
<td>—NH₂</td>
<td>—N—H</td>
</tr>
<tr>
<td>Phosphate</td>
<td>—H₂PO₄</td>
<td>—O—P=O—OH</td>
</tr>
</tbody>
</table>
Carbohydrates

“Hydrated” carbon

Generally: \((\text{CH}_2\text{O}_n)\)
Carbohydrates

“Hydrated” carbon

Generally: \((CH_2O_n) \rightarrow (C_6H_{12}O_6)\)

Simple sugars = monosaccharides or disaccharides

Complex polymers = polysaccharides

Monosaccharides exist as either 5- or 6-carbon rings (e.g., ribose [5-carbon] or glucose [6-carbon])
**MONOSACCHARIDES**

- Fructose
- Glucose (dextrose)
- Galactose*

**DISACCHARIDES**

- Sucrose (table sugar)
  - Glucose + Fructose
- Maltose
  - Glucose + Glucose
- Lactose
  - Galactose + Glucose

Polymers: × 100s or 1000s

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Carbohydrates

“Hydrated” carbon

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Simple sugars = monosaccharides or disaccharides

Complex polymers = polysaccharides

Monosaccharides exist as either 5- or 6-carbon rings (e.g., ribose [5-carbon] or glucose [6-carbon])

Polysaccharides are used as fuel or as structural support
Lipids

Also have C, H, O, but much less O → nonpolar and hydrophobic

Lipids are a BIG and diverse group of molecules, but triglycerides and phospholipids are two lipids that are of particular physiological concern
GLYCEROL

FATTY ACIDS

Palmitic acid, a saturated fatty acid

Oleic acid, a monounsaturated fatty acid

Linolenic acid, a polyunsaturated fatty acid
SEAL BLUBBER This cross section of a frozen seal shows the thick layer of blubber. Of the total area in the photo, 58% is blubber and the remaining 42% is muscle, bone, and visceral organs. The measuring stick is graduated in inches. [Courtesy of P. F. Scholander, University of California, San Diego]
LIPID-RELATED MOLECULES

PHOSPHOLIPIDS

Fatty acid

Glycerol

Fatty acid

Phosphate

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Nucleotides

In general, nucleotides play a major role in the storage and transmission of energy and genetic information.

Regardless of their job, nucleotides consist of:

1. + phosphate functional groups
2. 5-carbon sugar (ribose or deoxyribose)
3. Nitrogenous base
Nucleotides

In general, nucleotides play a major role in the storage and transmission of energy and genetic information.

Regardless of their job, nucleotides consist of:
1 + phosphate functional groups
5-carbon sugar (ribose or deoxyribose)
Nitrogenous base

Energy transferring nucleotides are things like ATP, ADP, NAD and FADH

Polymers of nucleotides—nucleic acids—carry genetic information (DNA, RNA)
Proteins

Proteins play many roles in our bodies, and are what make us...well...us. When you look in the mirror, you see your skin, hair, eyes; those are proteins. The differences in hair color (for instance) between individuals is due to differences in proteins.

Proteins are polymers of amino acids (20 total, 9 essential)
AMINO ACIDS

All amino acids have a carboxyl group (−COOH), an amino group (−NH₂), and a hydrogen attached to the same carbon. The fourth bond of the carbon attaches to a variable "R" group.

Can be categorized as

Essential

Non-essential

and can link together by peptide bonds to form

Oligopeptides (2–9 amino acids)

Polypeptides (10–100 amino acids)

Proteins (>100 amino acids)

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Proteins

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Proteins are polymers of amino acids (20 total, 9 essential)

Amino acids can arrange in any sequence—like the letters of our alphabet—to make 1,000s of “words”, which serve many functions in our bodies
Quaternary structure

Multiple subunits

Fibrous proteins

Globular proteins

Collagen

Hemoglobin
<table>
<thead>
<tr>
<th>First base in codon</th>
<th>U</th>
<th>C</th>
<th>A</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>Val</td>
<td>Val</td>
<td>Ala</td>
<td>Ala</td>
</tr>
<tr>
<td>Met</td>
<td>Ile</td>
<td>Ile</td>
<td>Thr</td>
<td>Thr</td>
</tr>
<tr>
<td>A</td>
<td>Ile</td>
<td>Ile</td>
<td>Thr</td>
<td>Thr</td>
</tr>
<tr>
<td>C</td>
<td>Leu</td>
<td>Leu</td>
<td>Pro</td>
<td>Pro</td>
</tr>
<tr>
<td>U</td>
<td>Phe</td>
<td>Phe</td>
<td>Ser</td>
<td>Ser</td>
</tr>
</tbody>
</table>

*STOP* indicates a stop codon.
How do genes (and proteins) change over time?

We now understand:

That our proteins are what make us…us

That the “instructions” for our proteins are found in our DNA, and that an individual protein is coded for by an individual gene (“one gene, one protein”)

So…what makes us different, and more importantly, what makes proteins change over time?
Consider a population of critters…
<table>
<thead>
<tr>
<th>Fur Color</th>
<th>Alleles</th>
<th>Genotype</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Homozygous</td>
</tr>
<tr>
<td>![Black Cat]</td>
<td>![</td>
<td></td>
</tr>
<tr>
<td>![Gray Cat]</td>
<td>![</td>
<td></td>
</tr>
<tr>
<td>![White Cat]</td>
<td>![</td>
<td></td>
</tr>
</tbody>
</table>
Consider a population of critters…

…this population has a certain genetic structure
...and so forth.

Don’t remember this mating scheme, but remember that if mating in our hypothetical population remains random, then the population structure will remain relatively stable over time.
Now, it’s snowing…who can hide, and who can’t?
Now, it’s snowing…who can hide, and who can’t?

...over time, the genetic structure changes.
Now, a river separates our population...
Now, a river separates our population…

…again, over time, the genetic structure changes.
How do genes (and proteins) change over time?

In both of these examples, the genetic structure of our population changed over time.

*This is the definition of evolution.*

Evolution accounts for many of the differences between us (eye color, blood type), but also between us and other species, because over very long periods of time, large changes can accumulate.

Remember that evolution affects populations, not individuals.
Evolution connection: proteins, carbohydrates, and nucleic acids

Digesting lactose with an enzyme

![Diagram of lactose digestion](image-url)

Lactose → Galactose + Glucose
Evolution connection: proteins, carbohydrates, and nucleic acids

Lactase to the rescue!

Lactose

Galactose

Glucose
Evolution connection: proteins, carbohydrates, and nucleic acids

Gene for lactase
Evolution connection: proteins, carbohydrates, and nucleic acids

10,000 years ago: 100% lactose intolerant

Lactose tolerance arises and increases in frequency.

Lactose tolerance arises several times and increases in frequency.

Understanding Evolution understandingevolution.org
1. Ancestral lactose control gene on chromosome 2
   - lactose intolerance

2. C nucleotide replaced by a T nucleotide
   - lactose tolerance

3. One of three single nucleotide changes
   - lactose tolerance

Evolution connection: proteins, carbohydrates, and nucleic acids
# Table 3.4

<table>
<thead>
<tr>
<th>Enzyme</th>
<th>Nonenzymatic $t_{1/2}$</th>
<th>Turnover number</th>
<th>Rate enhancement</th>
</tr>
</thead>
<tbody>
<tr>
<td>OMP decarboxylase</td>
<td>78,000,000 yr</td>
<td>39</td>
<td>$1.4 \times 10^{17}$</td>
</tr>
<tr>
<td>Staphylococcal nuclease</td>
<td>130,000 yr</td>
<td>95</td>
<td>$5.6 \times 10^{14}$</td>
</tr>
<tr>
<td>Adenosine deaminase</td>
<td>120 yr</td>
<td>370</td>
<td>$2.1 \times 10^{12}$</td>
</tr>
<tr>
<td>AMP nucleosidase</td>
<td>69,000 yr</td>
<td>60</td>
<td>$6.0 \times 10^{12}$</td>
</tr>
<tr>
<td>Cytidine deaminase</td>
<td>69 yr</td>
<td>299</td>
<td>$1.2 \times 10^{12}$</td>
</tr>
<tr>
<td>Phosphotriesterase</td>
<td>2.9 yr</td>
<td>2,100</td>
<td>$2.8 \times 10^{11}$</td>
</tr>
<tr>
<td>Carboxypeptidase A</td>
<td>7.3 yr</td>
<td>578</td>
<td>$1.9 \times 10^{11}$</td>
</tr>
<tr>
<td>Ketosteroid isomerase</td>
<td>7 wk</td>
<td>66,000</td>
<td>$3.9 \times 10^{11}$</td>
</tr>
<tr>
<td>Triosephosphate isomerase</td>
<td>1.9 d</td>
<td>4,300</td>
<td>$1.0 \times 10^{9}$</td>
</tr>
<tr>
<td>Chorismate mutase</td>
<td>7.4 hr</td>
<td>50</td>
<td>$1.9 \times 10^{6}$</td>
</tr>
<tr>
<td>Carbonic anhydrase</td>
<td>5 sec</td>
<td>$1 \times 10^{6}$</td>
<td>$7.7 \times 10^{6}$</td>
</tr>
<tr>
<td>Cyclophilin, human</td>
<td>23 sec</td>
<td>13,000</td>
<td>$4.6 \times 10^{5}$</td>
</tr>
</tbody>
</table>


1 The time that would elapse for half the reactants to be converted to product in the absence of enzyme.

2 The number of reactions catalyzed by a single enzyme molecule per second when operating at a saturating substrate concentration.

3 The increase in reaction rate achieved by the enzyme-catalyzed reaction over the noncatalyzed reaction.