Early in a burst of activity (0-5 seconds) most ATP will come from phosphagen system, later in the activity (5 seconds – 1 minute) ATP will be produced from glycolysis. If high levels of activity continue for an extended period, significant amounts of ATP may also be produced by aerobic respiration/oxidative phosphorylation.

Glucose is sometimes stored in a polymer called glycogen. The process of putting glucose in this form is called glycogenesis, while breaking the polymer down to release glucose is called glycogenolysis.

Lactate is a common endpoint of glycolysis. Lactate is often toxic at higher concentrations, so it is often converted to glucose in the liver.

The respiratory quotient (RQ) is measured as the ratio of CO_2 released to O_2 consumed. RQ will be highest when metabolism is fueled by carbohydrates.

The metabolic rate of an animal at a standard temperature, with no food, no stress and no activity is called basal or standard metabolic rate. The metabolic rate of an animal in its environment over a typical 24 hour period of activity is field metabolic rate. The greatest metabolic output for any single period (not sustained) is the maximum metabolic rate.

If an ectotherm has a metabolic rate (oxygen consumption) of 10 ml O_2 / g hr at 13 C and a metabolic rate 21 ml O_2 / g hr at 20 C, it has a metabolic Q_{10} of
Proportional change in rate = 21/10 = 2.1
That change occurs over 7 C. So, the rate of change over 10 C is roughly 2.1*(10/7) = 3. This is an estimation, we will talk about this in more detail in the next section of the course. The formal equation we have not covered yet is: $Q_{10} = \left(\frac{R_2}{R_1}\right)^{\left(\frac{10}{T_2-T_1}\right)}$
Where R_1 and R_2 are the rates and T_1 and T_2 are the temperatures. Substituting,
$Q_{10} = \left(\frac{21}{10}\right)^{\frac{10}{20-13}} = 2.1^{1.4286} = 2.89$

What is an oxygen debt? During the period that an oxygen debt is being "repaid" what is happening physiologically?
Replenishing phosphagen system, conversion of lactate or other glycolysis products, replenish oxygen stores in myglobin. See notes and text for details.

What is the Cori cycle? What role does this cycle play in regulating energy budgets and energy availability in animals?
Conversion of lactate from glycolysis back into glucose (glycolysis+gluconeogenesis). See notes and text for details on energetics and location of parts of cycle.

Discuss, in detail, the roles of insulin and glucagon in regulating the availability and amount of blood glucose, lipid stores, and glycogen. What processes does each hormone stimulate or inhibit?
Insulin stimulates glycogensis, short and long term storage. Glucagon stimulates glycogenolysis, lipolysis. See notes and text for details putting this in broader energetic context.

What is an energy budget (include descriptions of the various components of an energy budget). In class we discussed the fact that energy budgets are dynamic and change depending on the animal in the context of its environment. Give an example of some changes you would expect in an energy budget as an animals environment changed.
Review energy budgets, be able to reproduce one. How does allocation change over time or space for some of the organisms discussed?

What are the advantages/disadvantages of using lipids, carbohydrates and proteins as an energy and a form of energy storage. Which of these is the best storage medium, which is at immediate energy release? Translate this to animals in their environment – give me an example of an animals that relies primarily on protein vs. carbohydrates in their diet. What are the ecological implications of this diet for that animal?
Lipids are the densest in terms of energy content, carbohydrates have the highest assimilation efficiency, proteins the highest SDA. Review notes and text on assimilation efficiency, assimilation costs, and energy yields. We also discussed implications for various diets in ecological contexts.

Describe three methods of measuring metabolic rate. For each method, tell me what specific process is actually being measured. As a researcher, what are the advantages/disadvantages of each method?
Heat generation, O2 consumed, energy in – energy out, doubly labeled water. See notes and text for details.

At 800 torr and 25% O_2, what is P_{O_2} 200 torr?

The % saturation of blood is defined as the concentration of HbO_2 divided by the combined concentration of Hb and HbO_2.

A Bohr shift involves shifting of the oxygen disassociation curve to the right while Root effect involves a shift downward.

The profusion ratio in fishes is a measure of the proportion of ventilated water that actually comes into contact with gill tissue. The structures in fish gills that actually do the gas exchange are called lamellae.

Lungs that are difficult to expand (small increase in volume for a large change in pressure differential) are said to have low compliance.

Fishes that can switch from primary use of gills to primary use of lungs are called facultative air breathers, while those that can only use lungs are called obligate air breathers.

As respiratory structures, only gills provide a true countercurrent exchange with the respiratory medium. The next most efficient system is the crosscurrent exchange seen in birds.

Air or swim bladders evolved as structures to utilize atmospheric air for oxygen. In modern fishes, air bladders also serve functions as buoyancy compensation and sound production/detection.

Total oxygen capacity of blood is a function of blood volume, hematocrit, and percent saturation.

Describe the differences in atmospheric concentration, diffusion rate and solubility of O_2 and CO_2. What are the physiological and ecological implications of these differences.
O2 is 21% of atmostpheric air, variable in water based on temperature, salinity, mixing, and biological demand (culminating in some anoxic environments). CO2 dissolves more rapidly in water, alters pH though production of H and bicarbonate. See notes and text for details.

What type of fish would you expect to have the greatest gill surface area (corrected for body size) and why? For what type of fish would you expect to have hemoglobin with the lowest oxygen affinity and why?
Highest gill area in metabolically active, warm water, marine species (high demand and low O_2 availability). Low affinity means a curve shifted to the right, expected in high oxygen environment (cold, fresh water) with a high metabolic demand (small body, high activity). See notes and text for details.

Describe the advantages and disadvantages of using air vs. water as a respiratory medium. A number of animals use both, what are the advantages and potential disadvantages of being able to switch?
Water is 800x as dense, air contains more O_2. Oxygen in air has to be dissolved in water first, requiring moist respiratory surfaces on lungs (recall respiratory flux water loss). See notes and text for details.

What is the Henderson-Hasselbalch equation and why is it important in the physiology of gas exchange?
Describes CO2 behavior in water, alters pH (relate to Hb saturation curves, role of carbonic anhydrase, regulation of ventilation rate etc.). See notes and text for details.

Discuss the short term (acclimatory) and long term (evolutionary) changes you would expect to see in blood physiology of a mammal species living at high altitude.
Short term – release of 2,3 DPG (shift curve to right), erythropoietin, increased hematocrit. Longer term increased lung or gill area, decreased blood cell size (increasing surface area to volume), blood volume or hematocrit, Hb curve shift to the left (increased affinity). See notes and text for details.

When viewing the oxygen disassociation curves, what types of animals (answer in terms of activity, basal metabolic rate, and type of environment occupied) would you expect to be shifted to the right vs. shifted to the left? Explain why this pattern is advantageous for these animals in these environments (ie. **why** is the curve shifted the way it is).
A curve shifted left facilitates acquiring O2 from the environment, but makes it difficult to drop off at tissues quickly (low oxygen environment, low metabolic rate). A curve shifter right does the opposite (slower acquisition from the environment, more rapid release at tissues). See notes and text for details.

Explain (including a diagram) how physoclistic fishes inflate their air bladders.

Glycolysis in gas gland increases temperature, decreases pH, lowering Hb affinity and increasing PO_2. Counter current multiplier and counter current exchange maintain conditions (pH, temperature, PO_2) locally. See notes and text for details.