Cell function

Some of this will again be covered again in a few days, though in more detail.

Energy:

Like with chemistry, this is not a physics class, so we'll keep things simple.

Energy is the ability to do work (work is defined as causing movement).

There are two kinds of energy (and many “subtypes”) [OVERHEAD, not in text]

Kinetic energy - causes movement. For example:

- Muscles contracting
- Water heating up (movement of molecules increases)
- Light, radiowaves, etc. (movement of photons, although this gets deep into physics quickly)

Potential energy - energy that is stored up and can be used.

- Batteries - good example - provide electrical energy when needed.
- A bicyclist at the top of a hill.
- Chemical energy - energy stored up in molecules (as molecules break up, they can release lots of energy).

Laws of thermodynamics

1) The total amount of energy is constant (energy can not be created or destroyed).

2) When energy is transferred, some is lost due to heat. This heat is useless and is lost to the surroundings (entropy). Without an input of energy, things would tend to “fall apart” and become disordered (increasingly random).

[OVERHEAD, fig. 5.10, p. 80]. Energy is “lost” (converted into useless heat) during exercise.

Total energy = usable energy + unusable energy

The second law basically says that with every conversion of energy:

the amount of usable energy < total energy

Energy is renewed - the sun is continually pouring energy into the biosphere, so organisms have a usable source of energy. That's why biological systems are so ordered (a constant influx of energy).
Chemical energy is energy available from molecules. Hydrocarbons have lots of potential energy available that can be used (oil, gas, etc.). Sugars are the main source of energy for organisms.

[OVERHEAD, not in text]

Reactions can release energy, or use up energy.

The sum of all these reactions is often called the “cellular metabolism”.

Running, digesting, growing, reproducing, making sounds, etc. all require energy. Almost all work in cells (and therefore at a larger level) uses ATP.

ATP is a high energy molecule [OVERHEAD, fig. 5.12A, p. 82].

Adenine, ribose, & three phosphate groups (adenosine triphosphate)

Phosphate groups all have a (-) charge (thus repel each other). This is how some of the energy is stored (the phosphate groups don't want to be so close).

When energy is needed, ATP will split off one phosphate group and become ADP (adenosine diphosphate). This releases lots of energy.

Energy is transferred to other systems (molecules) by this phosphate group.

Termed phosphorylation.

All three types of work in the cell are powered by ATP [OVERHEAD, fig. 5.12B, p. 82].

Chemical work - building more complicated molecules (this almost always requires energy).

Mechanical work - moving muscles (the middle diagram is rather misleading muscles don't require ATP to move! (they need ATP to get ready to move).)

Transport work - provides energy to parts of the membrane that can then move substances against a gradient (active transport).

ATP cycle [OVERHEAD, fig. 5.12C, p. 82]:

ATP is renewable. ATP can be made from reactions that release energy (generally by breaking down sugars), and then used to provide energy for the three types of work described above.
Enzymes:

Briefly, enzymes are biological catalysts. The help speed up reactions that would take place anyway, but at a MUCH slower rate (so slow they'd be useless).

Remember, enzymes are proteins!

Even a reaction that releases energy still must overcome the “energy of activation”. This is a small input of energy that gets things going. Like our bicyclist at the top of a hill. She needs to move forward a bit before she gets the benefit of going down hill.

Another example: a gas stove. Mixing gas and air does not (by itself) cause an explosion. But very little additional energy (a match) will release enormous amounts of energy.

[OVERHEAD, fig. 5.13, p. 83]:

Enzymes lower this activation energy, and make it easier for the reaction to happen.

Enzymes are specific for the reactions that they control. Each reaction needs its own enzyme.

The stuff that an enzyme helps to react is called the substrate.

The substrate fits into a part of the enzyme called the active site.

When the substrate actually bonds (to the enzyme), it (the enzyme) often changes shape slightly to hold the substrate more securely (which also often facilitates the reaction).

The enzyme then helps to convert the substrate into products.

[OVERHEAD, fig. 5.14, p. 84]

The enzyme sucrase will split sucrose into glucose and fructose

substrate = sucrose

Sucrase binds to sucrose, adds water, (hydrolysis reaction), and releases finished products (glucose and fructose).

Enzymes can be denatured (they are proteins).

pH, salt, temperature, all affect the efficiency of enzymes.

These substances often interfere with hydrogen bonds, and cause the enzyme to loose its shape.

Some enzymes need cofactors (non-protein helpers, often inorganic substances like iron or zinc).
Others need coenzymes (often these are vitamins, which are substances we can't make).

Enzymes can be inhibited [OVERHEAD, fig. 5.15A, p. 85].

Some substances mimic the substrate and will bind to the active site.

This prevents the enzyme from doing its normal job, since the active site is now filled with something else.

This is called a competitive inhibitor

(By increasing substrate concentration, the effects can be minimized - enzyme is more likely to find the correct “substrate”).

Some substances change the shape of an enzyme.

They'll bind to a different part of the enzyme, change its shape, and now the enzyme can no longer attach to the substrate.

This is often an important way of stopping enzymes once they've done enough work.

Many substances are enzyme inhibitors:

Poisons - block enzymes needed for necessary reactions:

Cyanide interferes with ATP production (we'll see this again later).

Nerve gases interfere with nerve cells (cause muscles to spasm by not allowing neurotransmitters to be broken down - illustrates the importance of inhibition - the neurotransmitters MUST be stopped after they're done).

Pesticides work in a similar way.

Antibiotics inhibit important bacterial enzymes

Aspirin blocks enzymes responsible for “causing” pain.

The speed of enzyme controlled reactions can also vary due to:

The concentration of substrate

This will speed up the reaction, but eventually there will be so much substrate that the enzymes are working as fast as they can, and the speed increase will level off.

The concentration of enzyme

This will also speed up the reaction, but generally won't level off (unless we start adding so many enzymes that there are actually more enzymes than substrate (which would be silly)).