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Minute sketches for chunking and problem solving

Students are successful when they can (1) create minute sketch diagrams and models that capture a definition or a concept, and (2) use their minute sketches to produce logical solutions to novel problems.

Instructions for students for minute sketches: Four steps

1. From lecture notes or a text book chapter, identify an important process, concept or structure.
2. Write down the term for the process, concept, or structure, and then list the key words from the definition or explanation.
3. Create or find symbols for each key word or event.
4. Combine the symbols in a sketch that captures the definition or concept.

Step 1. Identifying important concepts or definitions.

Start with the most important item to learn, either in your notes or a book. As a beginner, you'll just have to make an informed guess as to which is most important. It doesn't matter if you're not exactly right. With practice, you can figure this out: the most important topics are the ones which, if you don't know them, will make it impossible to understand more of another topic. For example, if you're studying molecular genetics, then DNA is critically important; you can't understand anything else without it. The role of transfer RNA is less important; you can forget it, and still have a fairly complete explanation of many topics in molecular genetics, but you won't be able to solve every problem that involves the growth of new proteins. The molecular structure of ribose sugar is probably unimportant; you can forget it and might still solve every molecular genetics problem you're given.

Of course, if a teacher tells you which things are important, that will make this task simpler. However, it's still incredibly valuable to develop this skill on your own. You'll be making decisions on what is important to learn for the rest of your life. You'll save a lot of time if you can decide that many things are not worth studying.

In the examples I give you here, we'll capture (A) some basic chemistry, and (B) the complex biological process of DNA to RNA to Protein in minute sketches.

Step 2. Write down the term and key words from the definition or explanation.

(A) Key words for basic chemistry might include element, proton, neutron, electron, ion, specific important elements, water, crystal, covalent bond, sharing electrons, ionic bond, dissolved ions.

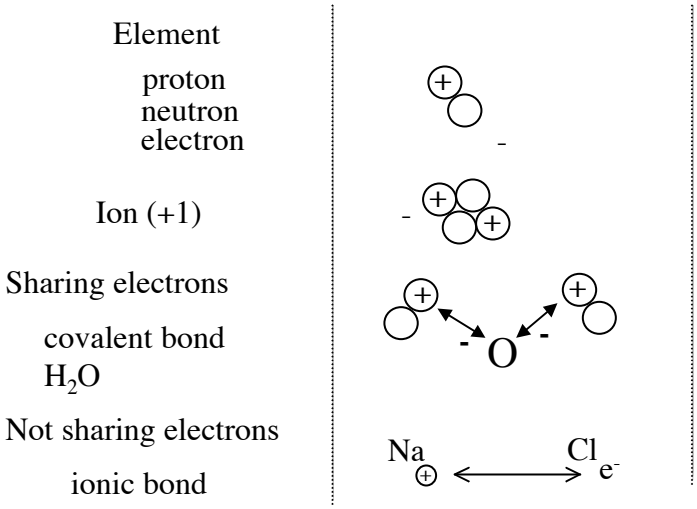
(B) Our second example involves DNA transcription and translation: the processes by which genetic material, a section of a DNA molecule, is first recopied as the related molecule RNA, and then the RNA sequence is used to assemble amino acid molecules in the correct order.Key words from a more complex concept, n might include: gene, promoter, exon, intron, RNA polymerase, messenger RNA, ribosome, transfer RNA, and amino acid. There are other possible terms to include, such as 'codon', 'anticodon', 'start codon', and 'stop codon' ; you decide when you've included all of those needed for the problems you'll have to solve.

Step 3. Create or find symbols for each key word or events. As you do minute sketches, you'll start picking up a set of symbols that you'll take from lectures or books or invent for

yourself. If you can use symbols that mean similar things each time you use them, you'll save time. It is important that the symbols in your sketch make sense to you. They do NOT need to make sense to others, but if you've got good symbols, other people will understand them.

For example, movement or time can be indicated by arrows. Small symbols can indicate individuals (individual people, animals, molecules, or whatever). Different small symbols can indicate different people, elements, molecules, or animals.

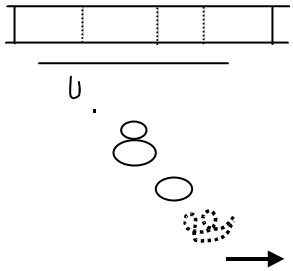
(A) A circle with a plus might be a proton; an empty circle a neutron, and a 'minus' sign an electron (an electron is much smaller than a neutron or a proton). Double arrows with a minus sign in the middle might indicate shared electrons, while double arrows that have a proton and an electron at opposite ends might indicate attraction of opposite charge without shared electrons in an ionic bond. Water molecules might have very tiny plus signs near the hydrogens in order to indicate that, even though the electrons are shared, the electrons spend more time near the oxygen, which gives the hydrogen a slight positive charge (on average) and the oxygen a slight negative charge. That might give us the following minute sketches:



(B) For our more complicated example, a double line might indicate DNA (which has two long paired strands) or a cell membrane (which has an inner and outer layer of molecules). Some possible symbols for our example include:

DNA: double line, with dotted lines across to indicate different parts of a gene (promoter, exon, intron).
mRNA: a single line
tRNA: a curved squiggly line
amino acid: a small square
ribosome, a small oval on top of a larger oval
RNA polymerase protein: a solid or dashed circle
Some other protein: a twisting dashed line
Time or movement: an arrow

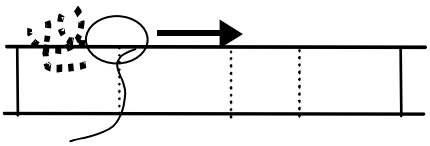
Here are the symbols, in the same order as the terms above:



Step 4. Combine the symbols in a sketch that captures the definition or concept.

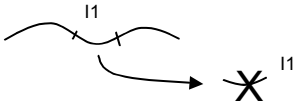
(A) I've already done that in the sketch above for our basic chemistry example.

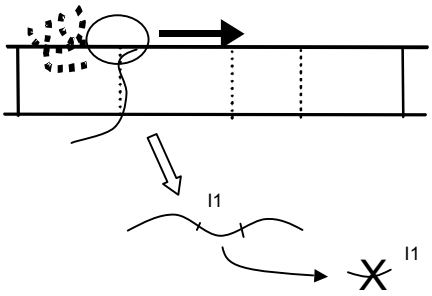
(B) For our more complex example, we might start with:



Here, I've started with DNA transcription: two parallel horizontal lines for DNA, a transcription factor plus RNA polymerase bound to the DNA, some messenger RNA starting to be produced, and with four segments of the gene. The four segments represent the promoter region, then the first of two exons, then an intron, and then the second exon. For a novice, this is a good sketch for a single chunk.

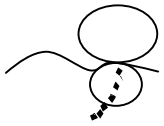
Below is the second part, mRNA intron removal:

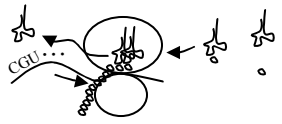




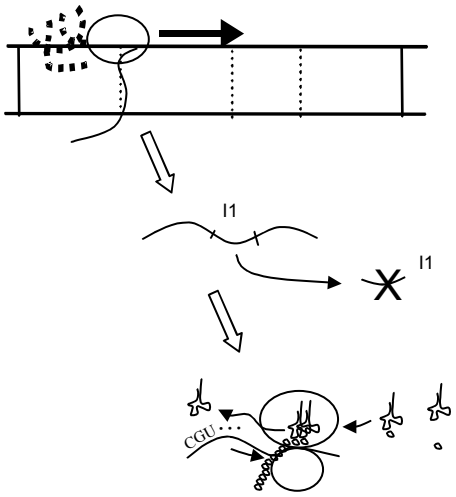
To the <u>right</u> <u>above</u>, I've combined the two parts in a single sketch. Here I've shown the new mRNA, out of which the copy of the intron is cut and broken down.

Next (below left) the two exon segments of the mRNA have been reconnected, have encountered a ribosome (the two ovals), and the RNA is moving through and being translated into a protein (the dots). Below on the right I've shown the same thing, but also shown a triplet codon (CGU) and transfer RNA coming in from the right. tRNA needs to have a correct amino acid bound to the tRNA, and then the tRNA-amino acid pair can move into the ribosome, where it binds to the correct codon gives up the amino acid to the growing protein.





A novice would learn each of these separately, each as a single minute sketch, and each as one chunk. An expert might hold the entire thing as a meta-chunk (several chunks connected to allow the group to be a single item in working memory)—the sketch below.



Realize that to create and use minute sketches, you first have to hear about and <u>understand</u> the whole process. Without an explanation, a minute sketch makes no sense at all. However, once you've read the chapter or heard the lecture, the sketch actually captures what happens in DNA→ RNA→ Protein. One or more transcription factors (or enhancers) plus RNA polymerase bind to specific sequences of DNA, allowing RNA polymerase to move along the DNA and make an RNA copy, including both exons and introns. Introns are cut out of the RNA strand, and the exons become the messenger RNA. mRNA encounters a ribosome. RNA begins to move through the ribosome. Transfer RNA's, each carrying their specific amino acid, bind to the mRNA in the ribosome, and their amino acid is added at the end of the growing chain of amino acids. Eventually, the ribosome reaches the end of the mRNA, and the chain of amino acids, now a protein, is freed.

Notice that there's nothing in here that isn't needed; no extra lines, no colors, no shading (except that the proteins have more dots than needed—you could use fewer dots). That makes your minute sketch quick to draw and simple to think through (and keeps it the size of a 'chunk'). And notice: there are no words on the diagram! At most, there are only single letters or initials, but no abbreviations (when you can, don't even have letters on the sketch!). Don't ever break this rule. When you need to know words, combine minute sketches with *folded lists*. With practice and resketching, your minute sketches become simpler: