A Literary Learner Case Study

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TE 846: Accommodating Differences in Literary Learners

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The subject of this case study was Nick, a 16 year old boy that I have known for 6 years. He has lived in the Lansing area his entire life, but is currently a school of choice student enrolled in Holt Public Schools. Nick is my next door neighbor and he was a student in my 7th grade science class 4 years ago. While I know a significant amount about Nick and his reading abilities I decided that it may be best to obtain some more specific information from an English language arts teacher that he has had. In speaking with his former English language arts teacher, my own thoughts were affirmed. She indicated that Nick is a fairly strong reader, however, there were two slight concerned that she expressed. First, she felt that at times, Nick rushed through reading assignments and thus did not fully comprehend what he had read and that secondly, he disliked using graphic organizers. As she pointed out, this was odd, given that in her experience, most students found much value in organizing the information they read into some sort of graphic organizer. When I asked the former English language arts teacher what she thought would be most beneficial to Nick in my working with him she indicated perhaps introducing him to some reading strategies that would force him to slow down and spend more time interacting with the text, along with introducing him to some graphic organizers that he had not yet used.

Before beginning my case study I spoke with Nick's mother and father to ask for their permission for Nick to participate—they agreed. My first meeting with Nick to discuss and begin the case study was really quite informal. Nick was outside playing basketball in the cul-de-sac and I stepped out to explain what the process would be like. I explained to Nick that we would meet 2 or 3 times during which we would read some interesting science text and work on some reading comprehension strategies. I explained that the purpose of the case study was for me to develop lessons that I could then later use in my own teacher experience. I asked Nick if he had any questions about what he and I were to do. He did not and I informed him that if he

ever had questions about what we were doing or why we were doing it that he should feel comfortable asking. I then asked Nick to complete the "Textbook Reading Strategies Inventory" (See Artifact 1.1). I handed Nick the assessment and asked him to complete it on his own in the comfort of his own home. I informed him that he should answer each question honestly and ensured him that his responses would in no way change my personal view of him as a young adult. I also reminded him that I've had him as a student and already had some indications of how some of the questions should be answered. Nick and I made plans to meet for our first lesson and I asked him to complete the assessment (inventory) within the next day and return it to me. Nick returned the assessment to my home half an hour later! (**Standard I**)

Upon receiving Nick's "Textbook Reading Strategies Inventory" I decided it best to carefully look it over and compare what it said, to the information I had gathered from his former English language arts teacher. Of particular interest to me was his response to two questions. First, Nick indicated that he was very familiar with "drawing schematic maps of textbook information", but that he rarely, if ever, uses this strategy. Second, Nick indicated that he was not at all familiar with "multistep reading strategies such as SQ3R" and therefore, that he rarely, if ever, uses this strategy. The information that I learned from his "Textbook Reading Strategies Inventory", did in fact confirm what his former English language arts teacher had said. (**Standard III**)

In light of the information I gained from Nick's completed "Textbook Reading Strategies Inventory" I decided it best to look at the Michigan High School Content Expectations (HSCEs) pertaining directly to reading. While there are many reading related HSCEs I decided to focus my case study and lessons with Nick on two:

- **CE 2.1.1** Use a variety of pre-reading and previewing strategies (e.g., acknowledge own prior knowledge, make connections, generate questions, make predictions, scan a text for a particular purpose or audience, analyze text structure and features) to make conscious choices about how to approach the reading based on purpose, genre, level of difficulty, text demands and features.
- **CE 2.1.7** Demonstrate understanding of written, spoken, or visual information by restating, paraphrasing, summarizing, critiquing, or composing a personal response; distinguish between a summary and a critique.

There were two other goals that I sought to pursue through my lessons with Nick which do not directly appear in any HSCE. My first goal was that Nick would become familiar with at least one reading strategy that would enable him to read at a slower pace, thereby increasing his comprehension. My second goal for Nick was that he would be able to identify and use at least one graphic organizer that he found useful. (**Standard I, II, and III**)

Both reading lessons that I taught Nick occurred in my home at my dining table. This was not the first time that Nick was in my home. He has been in my home to babysit my children and to have meals with my family and me. I feel that Nick was quite comfortable in my home. I arranged for a babysitter to care for my children in her home while conducting my reading lessons with Nick. There was minimal, if any, outside distraction while Nick and I worked together. As previously stated, Nick and I have known each other personally and professionally for quite some time. I think that this greatly contributed to the relaxed and caring nature of the setting in which we worked. Available for Nick at each of our lessons were lined notebook paper, Post-it® notes, and index cards, highlighters in various colors, pencils, and pens. (**Standard IV**)

Before beginning our first reading lesson Nick and I talked about football camp. It was the first week that he had been out of school for the summer and he was super excited to tell me about the happenings of the day at football camp. Our actual lesson began with me asking Nick to describe what he does when a teacher assigns a reading as homework. He said that he "sits down and reads it". As I asked for further clarification Nick indicated that if there is an introduction or a summary to the reading he will occasionally begin by reading those, but that he usually just started with the "first word and stopped at the last word". I asked him how that worked for him. Did he feel that this was an effective strategy and was he easily able to recall what it was that he had read? Nick replied that he had "never really thought about whether or not it worked" he just "did it to get it done". He quickly agreed with me when I suggested that reading it to get it done was probably not the most effective reading strategy and that he might benefit from using a strategy that would require him to slow down and more deeply comprehend what he was reading. (**Standard III**)

Ehren (2005) suggests "packaged strategies", reading strategies that include multiple strategies require more engagement with text and thereby increasing the likelihood that an individual will more likely comprehend what they have read (p. 317). SQ3R (**S**urvey, **Q**uestion, **R**ead, **R**ecite, and **R**eview) is a "packaged strategy" that requires the reader to become more engaged with the text that they are reading.

I provided Nick with a copy of "The SQ3R Reading Strategy" handout (See Artifact 2.1). We read the handout aloud together (taking turns) and discussed each component of the unique "packaged strategy". As we read through the handout I indicated things that would probably not apply to the reading that we would be doing today (i.e., the reading we would be doing did not contain an introduction or a summary, therefore, we would not read through them during the

"Survey" part of SQ3R). Nick was quite surprised that there were 2 steps in this strategy before you actually got to the "Read" component. It was obvious at that point, that Nick had little experience with pre-reading strategies. (Standard V)

The textbook that I chose to use for our lessons was a unique text and was not your typical high school textbook. The book I used, *Exploring the Way Life Works: The Science of* Biology contains most of the same information found in a high school biology textbook but it is written in a more basic and concise format. What however, drew me to use this text was the interesting analogies and illustrations that are found throughout the text (See Artifacts 3.1, 4.1, and 5.1). Students are more likely to be motivated to read a text if they find it interesting and when students are motivated to read a text their comprehension increases (Guthrie, et al., 2004, p. 407). (**Standard III**)

After having discussed "The SQ3R Reading Method" handout, we began our first reading—"Making Bonds"—together (See Artifact 3.1). We began by **survey**ing the section. We went through the bulleted list for "Survey" from "The SQ3R Reading Method" handout. As we surveyed we also completed the "Question" part of the SQ3R reading strategy. A small discussion ensued as we began surveying. Nick wondered what he should do with the questions we were beginning to ask. I asked Nick if he thought it would be just enough to think of the questions without writing them down and move on with the reading. He did not think that this would be effective and I agreed with him. Nick chose to write the questions on the index cards that were available for his use (See Artifacts 3.2, 3.3, and 3.4). I asked why he had chosen index cards and I found his response to be quite thoughtful! Nick indicated that he usually creates flashcards after he is done reading, especially if the reading contains a lot of vocabulary. He explained that it made sense to create them now, while he was asking questions, rather than later

after he was completely done reading. I asked him if he had ever done it that way before and he said "No, it just came to me". As suggested by "The SQ3R Reading Method" Handout, Nick developed a question based on the title of the section and each of the two headings within the section. (**Standards I, V, and VI**)

We read the section aloud, taking turns. Before beginning the actual reading Nick decided that he would highlight the important and main ideas that he read. I asked what approach he would take when doing so and he replied that he would "read from heading to heading" and then "stop to highlight" what he had just read. I knew that Nick had had some experience and instruction in highlighting as these were skills that I stressed when I had him in my 7th grade science class. Occasionally, as we read, Nick would glance at the index cards containing his questions (he had neatly laid them out in front of him so that they were visible while he read). I believe that this indicated he was actively thinking about what he was reading and he was probably looking at the cards when he had read an answer to one of his questions or when he needed a slight reminder of what his questions were. None the less, I was impressed that he did this on his own. After highlighting the first small section, Nick noted that "some of the reciting actually happens while you read". I was excited by his observation that highlighting plays a role in both "reading" and "reciting" and praised him for it! (**Standards I, V, and VI**)

When the reading of the short section had commenced Nick immediately, without my prompt, reaching for his questions (the index cards) and began answering them on the opposite side he had written the question on. It was clear that Nick was beginning to understand the steps and components of the SQ3R reading method. After Nick had completed answering the 3 questions on his own we discussed his answers to the questions—a way for me to monitor his understanding and ability to comprehend what he had read. For his first question (See Artifact

3.2)—"Is it about money?"—he had simply written "No" as his answer. I asked him how we might extend the answer to be more specific and he then added what it was (atoms sticking together) to his original response. (**Standards I, V, and VI**)

I pointed out to Nick that in the short time frame of the lesson there wouldn't really be much time to review. Instead we discussed what he could or would do to review. Nick indicated that to review he would reread the words that he had highlighted as well as to study from the flashcards (questions and answers) he had written.

Upon completion of me modeling and us working though a section together I decided that Nick was ready to read a section on his own (See Artifact 4.1), using the SQ3R method. I provided Nick with the next section in the book and asked him to read the section using the SQ3R reading strategy. I watched Nick as he worked and observed the following:

- he surveyed the section, writing questions on index cards (See Artifacts 4.2, 4.3, and 4.4)
- he read the text, small sections at a time, going back to highlight main and key ideas (See Artifact 4.1)
- while reading he would occasionally glance back at the questions he had written
- after he read the section he wrote answers to his questions on the reverse side of the index card (See Artifacts 4.2, 4.3, and 4.4)

When Nick indicated that he we finished I asked him to complete a "Quick Write" (See Artifact 4.5). In my verbal instructions to him I told him that the point of the quick write was to determine whether or not he was able to comprehend what he had read and that he should answer the question the best he could without looking back at the section, the highlighting he had done, or the questions and answers he had written. Based on the outcome of the reading we had

previously done together I expected Nick's response to be more detailed. While Nick's response is not incorrect it lacks a bit of detail. I was intrigued by the fact that Nick recalled examples of energy transfer—a bird flapping its wings, a clam opening its mouth and a tree making a new branch—as this was not asked for in the question. It is interesting to me that he could recall detailed examples of energy transfer, but that he couldn't be more specific about the actual transfer of the energy. I did not discuss his individual work with him that day, as I read and looked over it all after he had returned home. Before we ended for the day I asked Nick a few questions to prepare for our next lesson. I reminded Nick that on his initial inventory questionnaire he indicated that he was pretty familiar with creating schematic maps and using graphic organizers, but that he rarely, if ever, did so (See Artifact 1.1). I asked him why. Nick responded by saying that he had a hard time learning and reviewing from them. They were a sort of "visual nightmare" to him. I then asked Nick if he would be willing to do a little homework for me and he agreed to. So, I gave him the next section in the book (See Artifact 5.1) and asked him to read it using any strategy or strategies that he prefers to use.

After my quick conversation with Nick about his lack in graphic organizer use I was determined to find a graphic organizer that would aid his comprehension, but would not be a "visual nightmare" for him. After a quick Google® search I came across a graphic organizer that I have seen a colleague of mine use before, with much success—"The FRAME Routine". After reviewing its use and components I decided that it may not be such a "visual nightmare" for Nick and decided that we would give it a try. (**Standards III and V**)

My second lesson with Nick occurred about 1 week after the first and we quickly reviewed the SQ3R reading method that I had previously taught him. I asked him what his overall thought about the method was and he said that he found it useful, but was surprised by

how long it took to read a section using that method compared to the method he was used to using. I asked him to clarify what he met and he indicated that SQ3R forced him to slow down and think more about what he was reading. This was the intent in my choosing the SQ3R strategy for Nick. He needed to learn a strategy that would cause him to slow down and read with intent.

Nick showed me the highlighting that he had down while reading the homework assignment that I had assigned him and he indicated that he did not actually use the SQ3R method that I had previously taught him. I assumed that he hadn't as he indicated that it was time consuming and he had just finished school for the summer. I introduced Nick to "The FRAME Routine" graphic organizer (See Artifact 5.2) and asked him what his first impression was. He said it wasn't a "mess" to look at. He was able to easily identify the structure of the organizer and said that he would "like to give it a try". Nick easily predicted that the "Key Topic" box should be the title of the section—"Life and the Laws of Energy". I praised his thought and we filled in the box together. I then explained to Nick that we needed to briefly explain what the key topic was about in the "is about…" box. This was not as easy for Nick. I helped Nick by asking him some guiding questions. Where does the energy originally come from? "The sun," he replied. And what does that energy help to create here on the planet Earth? "Life." And what is "life" made up of? "Molecules." I explained that he had it…we just needed to put it all together and he then filled in the "is about…" box. Together, Nick and I completed the first "Main Idea" and "Essential Details" column. Nick found this task pretty simple as he had already highlighted these items when he read the text. (**Standards V and VI**)

I asked Nick if he felt prepared to complete the last two columns on his own and he was, so he did. While he worked I noticed that he worked hard to piece together the bits he had

highlighted into phrases that were understandable. Not only did he refer back to what he highlighted, but he also referred to the illustrations that were in the text. As he worked he mentioned that the illustrations and analogies were helpful in better understanding what the text was saying. When Nick had complete the remaining columns I asked him to write a two to three sentence summary of the section in the "So What? (What's important to understand about this?" box. Again, I did not review Nick's work until he had returned home, but I must admit that I was quite impressed with the details he included in the organizer and I was VERY impressed by his ability to summarize the information in just two sentences. His summary was concise and right on point! (**Standards I, V, and VI**)

The following day I knocked on Nick's door and asked him to complete the brief "Reading Strategies Post Assessment" questionnaire (See Artifact 6.1). He completed it later than evening, in the comfort of his own home, and returned it to me early the next morning.

In reflecting on whether or not my objectives and goals were met through these reading lessons I stumbled across several findings and a few things that I would change if I had it to do all over again. First, I do believe that my lesson objectives and goals were met. Nick clearly was introduced to a reading strategy, SQ3R that required him to slow down and work harder to comprehend what he was reading. On the post assessment questionnaire (See Artifact 6.1) Nick stated that he did find the SQ3R strategy to be useful and that it would work well when he was given a reading assignment from a textbook to complete. While Nick did seem to comprehend the over-arching main idea of the text that he read independently using the SQ3R reading method, I was slightly concerned about the lack of detail he was able to provide. In the future I think that it may be helpful to provide students with a specific reason for reading (i.e., I could

have told Nick that his purpose for reading that section from the text was to answer the question "Briefly explain how energy is transferred from one molecule to another."—the question that he would later answer on the quick write assignment). Another of my goals for Nick was that he would be able to use a graphic organizer to better help him comprehend what he has read (and one that wouldn't be such a "visual nightmare"). In my opinion, this was the most successful of my lessons. Nick was able to successfully use "The FRAME Routine" organizer to organize the information he read. I was shocked to read on the post assessment questionnaire that he didn't feel the organizer helped him better comprehend the information. It seems to me, based on the summary that he was able to write, that the organizer helped him tremendously.

The reading lessons that I conducted in this case study have led me to realize the importance of implementing more reading and reading strategy lessons into my science classroom. If my students are to comprehend that information which I ask them to read, I must also provide them with the tools—strategies—they need to do so.

References

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Artifact 1.1

Textbook Reading Strategies Inventory

Adapted from Textbook Reading / Study Strategies Inventory (TRSSI)

Directions

The purpose of this scale is to learn more about your perceptions of various reading strategies. We are interested in knowing how familiar you are with different strategies, how effective you feel the strategies are in helping you learn, and how often you use the strategies to read. Rate each of the strategies below on a 1-5 scale (1 = low; 5 = high) in terms of *familiarity* and *use*. Circle the number of your rating for each strategy in the appropriate column. For example, you may be very familiar with how to outline textbook chapters, so your *familiarity* rating might be a 5. However, because outline is very time-consuming, you rarely use the strategy, so your *use* rating might be a 2.

Strategy	Familiarity					Actual Use				
Identify prefixes and suffixes to pronounce words or get the meaning of words	1	2	(3)	4	5	1	(2)	3	4	5
Use context clues to get the meaning of words.	1	2	(3)	4	5	(1)	2	3	4	5
Use the glossary or dictionary to define words in textbooks	1	2	3	4	(5)	1	2	(3)	4	5
Conduct a chapter preview before you read	1	2	3	4	(5)	1	(2)	3	4	5
Read chapter introduction and summary before reading the whole chapter	1	2	3	4	(5)	1	2	3	(4)	5
Underline or highlight key concepts in the textbook	1	2	3	(4)	5	1	2	(3)	4	5
Make notes on key concepts presented in the textbook	1	2	3	(4)	5	1	(2)	3	4	5
Take notes on key concepts presented in the textbook	1	2	3	(4)	5	1	2	(3)	4	5
Outline textbook information	1	2	3	4	(5)	1	2	3	(4)	5
Create tables or charts of textbook information	1	2	3	(4)	5	1	(2)	3	4	5
Draw schematic maps of textbook information	1	2	3	4	(5)	(1)	2	3	4	5
Use study questions presented in textbooks to guide your reading or review of a chapter	1	2	3	4	(5)	1	2	3	(4)	5
Develop flashcards of key textbook information	1	2	3	4	(5)	1	2	3	(4)	5
Use chapter headings and subheadings to guide reading	1	2	3	(4)	5	1	(2)	3	4	5
Monitor your understanding while you read, and take action to use "fix-up" strategies when you don't understand	1	2	3	(4)	5	1	(2)	3	4	5
Identify the main ideas of paragraphs as you read	1	2	3	4	(5)	1	2	(3)	4	5
Identify the most important details as you read	1	2	3	4	(5)	1	2	(3)	4	5
Use paragraph organization (such as cause and effect or problem and solution) to help you understand as you read	1	2	3	(4)	5	1	2	(3)	4	5

Use punctuation clues to help you understand difficult sentences	1	2	3	4	5	1	2	3	4	5
Use typographic aids such as boldface type and italics to help identify key information	1	2	3	4	5	1	2	3	4	5
Use multistep reading strategies such as SQ3R	1	2	3	4	5	1	2	3	4	5
Relate new information to what you already know	1	2	3	4	5	1	2	3	4	5
Create mental pictures or images to envision what you are reading	1	2	3	4	5	1	2	3	4	5
Anticipate or predict what the author will say next as you read	1	2	3	4	5	1	2	3	4	5
Predict questions teachers might ask on tests	1	2	3	4	5	1	2	3	4	5
Write summaries to reflect on key information in chapters	1	2	3	4	5	1	2	3	4	5
Adjust your reading rate to your purpose for reading the level of difficulty of the material	1	2	3	4	5	1	2	3	4	5

Artifact 2.1

The SQ3R Reading Method

The SQ3R reading method is designed to help you study your textbook and apply reading and note-taking skills. The letters in SQ3R stand for five steps: survey, question, read, recite, and review. These steps will help you gain more from what you read and be better prepared for quizzes, tests, and exams. On other words, you will maximize the return on your time investment for reading! Yes, it takes more time that just reading the words, but have you noticed that just reading the words in your text is a waste of your valuable time. Consider SQ3R an efficient way to read, study, and create a study guide all in one system!

S = Survey

- Read the title of the chapter or the article.
- Read the headings and subheadings.
- Read the introduction and summary to get an overview of the main ideas.
- Read the captions under the visual aids.
- Read any study questions and vocabulary terms at the end of the chapter or article and use them as goals in your reading.

Q = Question (while you survey)

- As you read each of the above parts, ask yourself what is meant by the title, headings, subheadings, and captions. Make good questions about each.
- Ask yourself what you already know about the subject.
- Ask yourself what the teacher said about the assignment in class or what was given out as a handout.
- Ask yourself what you want answered after reading the assignment.
- Ask yourself what you will have to do with the information.

R = Read

- Read and think actively.
- Look for main ideas and supporting details. Use outlining, underlining, and highlighting.
- Read to answer questions that were raised in the question step.
- Read carefully all of the <u>underlined</u>, *italicized*, and **boldfaced** words or phrases.

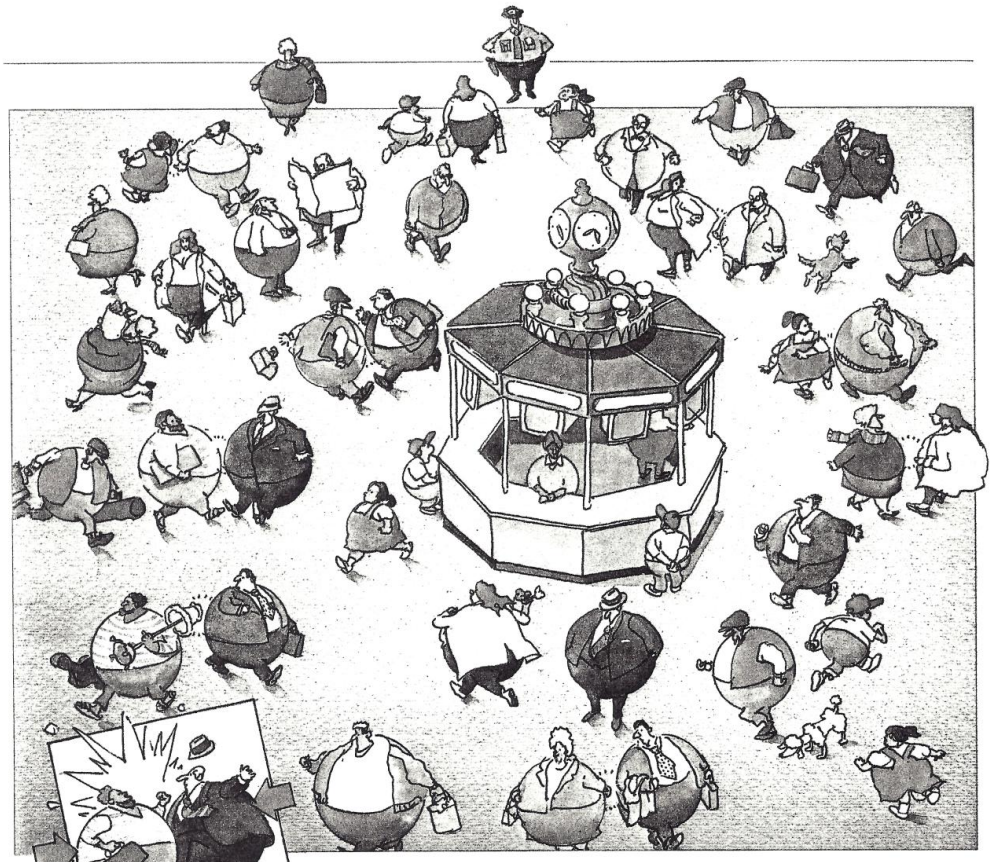
R = Recite

- Use good judgment about places to stop and recite.
- Use outlining, underlining, and highlighting skills. Do not underline or highlight long passages. Mark after and you have read AND understand it.
- Write your own summary statement of each section.
- Quiz yourself on the main points.
- Connect new material with what you already know about the subject.
- Write questions on any material you do not understand and ask your teacher to explain it.
- Write the answers to the questions from the QUESTION step.

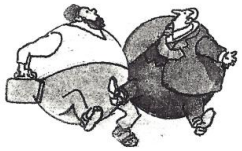
R = Review

- Look over your outlines, underlining, highlighting, and any notations you made in the reading.
- Briefly study the main ideas to keep the information fresh in your mind.
- Make practice test questions from review notes.

Artifact 3.1



Sometimes forceful collisions can bond atoms together into molecules...

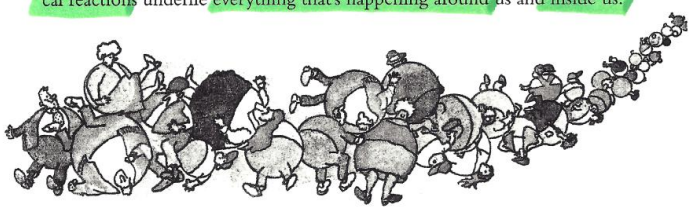


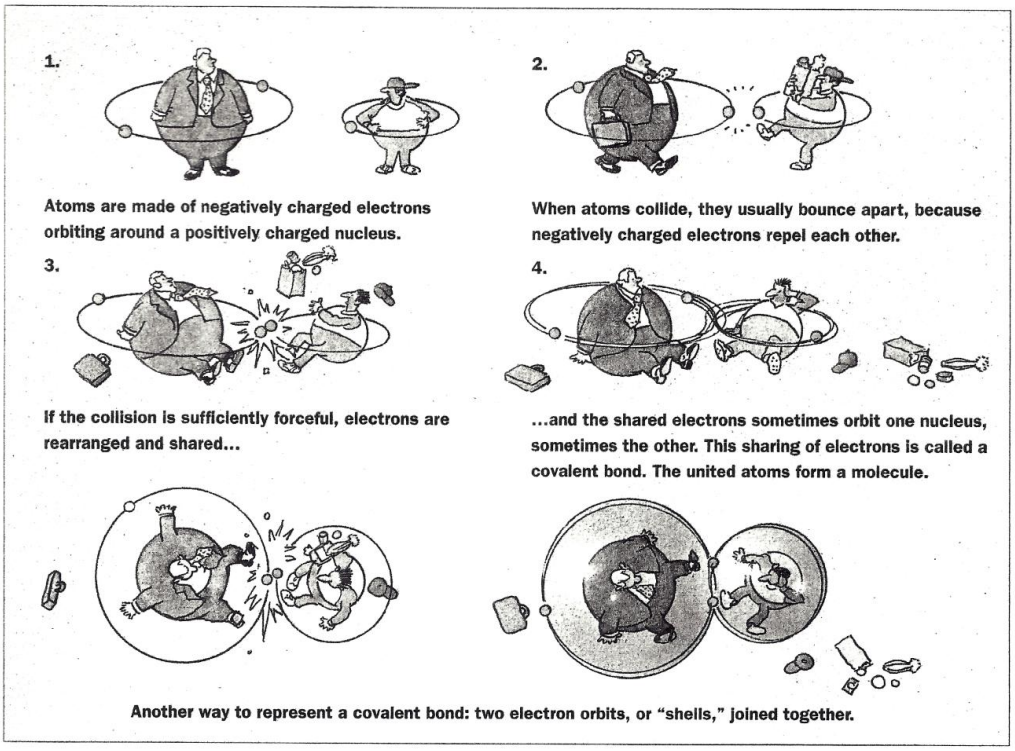
...theoretically, successive collisions could form a chain of molecules.

3.1 Making Bonds

A Chaos of Collisions

In New York City's Grand Central Station, busy travelers dash about in seemingly random fashion on their various missions. Collisions inevitably happen. Imagine that some of these commuters collide so forcefully that they stick together permanently! Now imagine these commuters as atoms, which also bump into one another constantly. When they meet with the right fit and sufficient force, they form a chemical bond — and a molecule is born. Such chemical reactions underlie everything that's happening around us and inside us.





Another way to represent a covalent bond: two electron orbits, or "shells," joined together.

How Atoms Stick Together

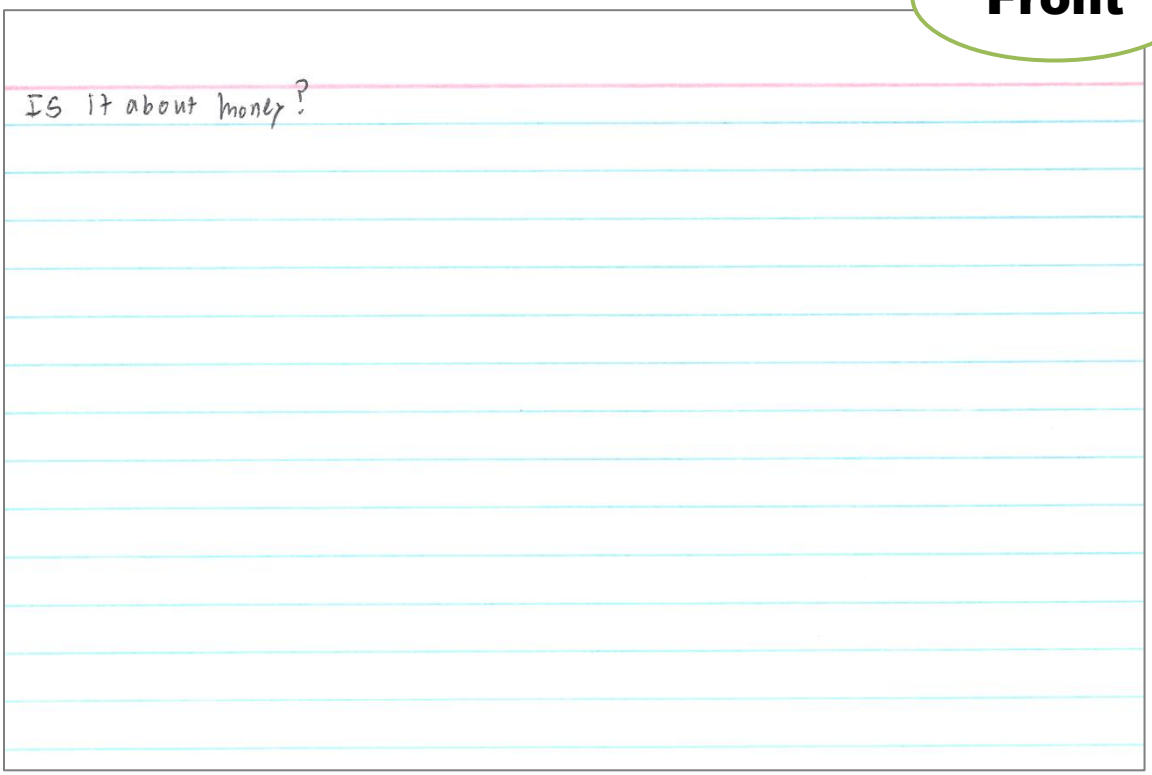
Let's back up a step and take a closer look at the atom. It consists of a positively charged nucleus — containing positively charged protons and uncharged neutrons — which is orbited by energetic, fast-moving, negatively charged electrons. When atoms collide, like the Grand Central commuters, their orbiting electrons push them apart, because like charges repel. However, as atoms careen through space, they possess what is called kinetic energy — the energy of motion. If the kinetic energy of two colliding atoms is great enough, it overcomes the repulsion of their electrons and a chemical reaction occurs, causing a rearrangement of electrons and uniting the atoms. Some of the atoms' electrons become *shared* by the two of them, producing what is called a covalent bond. These are strong bonds. They hold life's key atoms — carbon, hydrogen, oxygen, nitrogen, phosphorus, etc. — together in simple molecules, and they join those simple molecules together in chains.

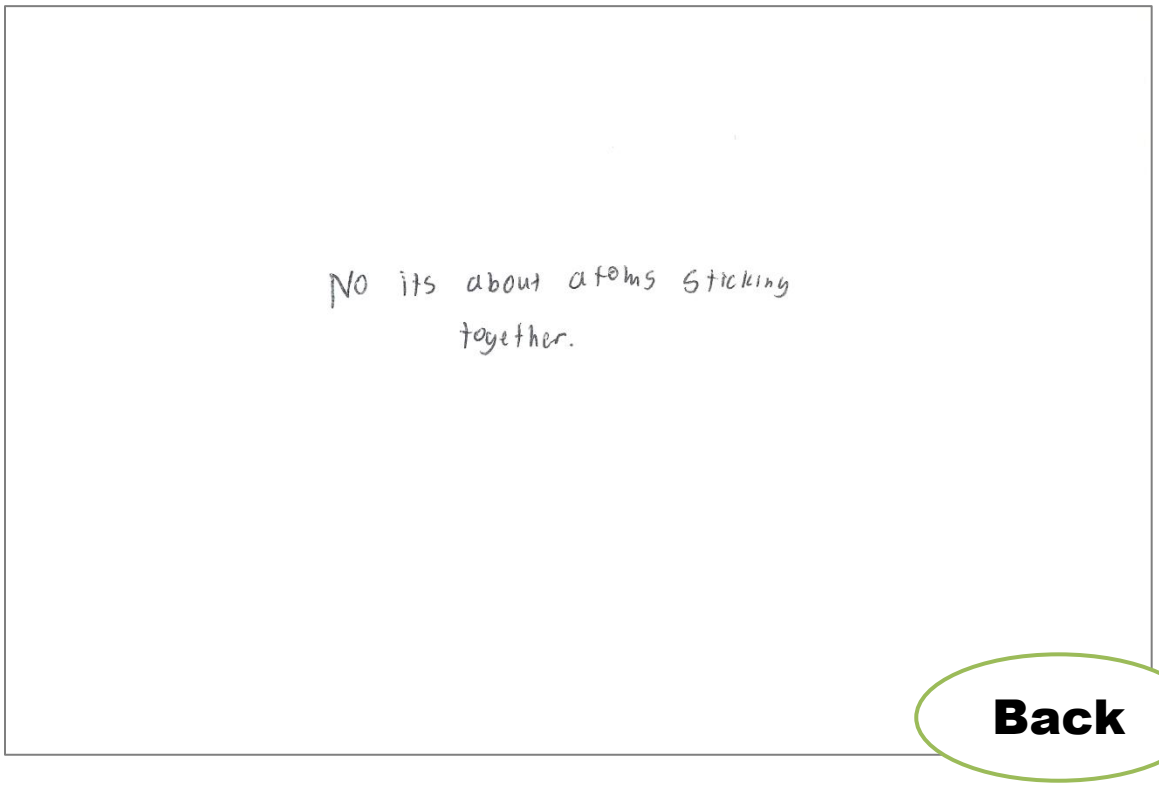
Bonds are also a reservoir of the energy that went into making them. That energy, like fuel, can be put to work in cells to accomplish life's feats of moving, growing, and reproducing.

For every atom, the number of positively charged protons in the nucleus equals the number of negatively charged electrons orbiting the nucleus; therefore, overall the atom is neutral. Each kind of atom has a different number of protons in its nucleus — and, consequently, a matching number of electrons in orbits — which accounts for atoms' different diameters and masses. Oxygen, for example, contains eight protons; carbon, six; hydrogen, one. There are over 100 known kinds of atoms in the universe. Only about 20 are abundant in living organisms.

Artifact 3.2

Front





Back

Artifact 3.3

Front

Is it about things running into each other?

Atoms Colliding making molecules

Back

Artifact 3.4

Front

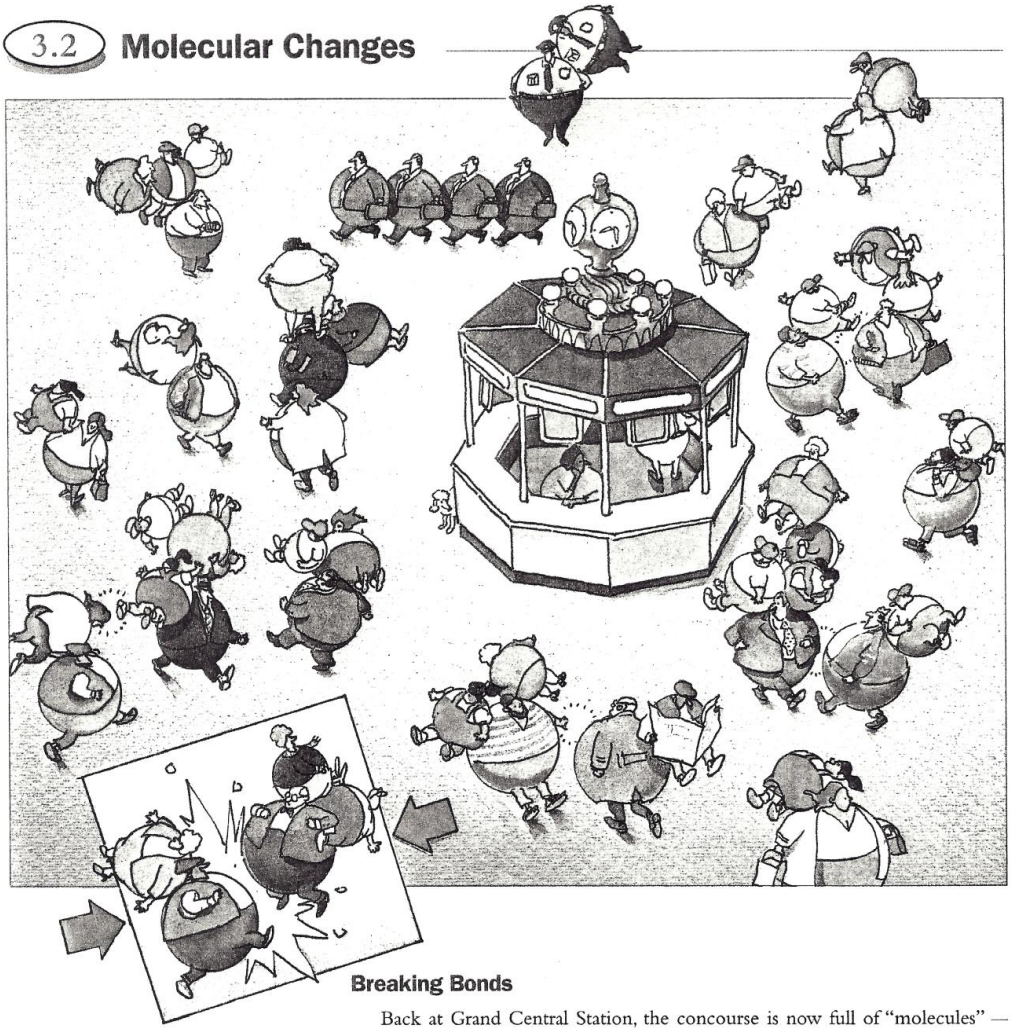
How do atoms stick together?

Back

Atoms collide with enough kinetic energy they overcome the repulsion and unite sharing electrons.

Artifact 4.1

3.2 Molecular Changes

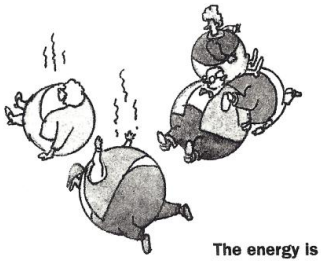


Breaking Bonds

Back at Grand Central Station, the concourse is now full of "molecules" — human "atoms" stuck together as a result of earlier collisions. In their ongoing mad dash for their trains, these molecules will frequently bump into each other without effect. But, now and then, a collision with more than the usual force and at just the right angle will cause the bonds between atoms to break. When a bond breaks, the shared electrons fall back into the original orbits around the separated atoms, releasing the energy in the bond as heat.

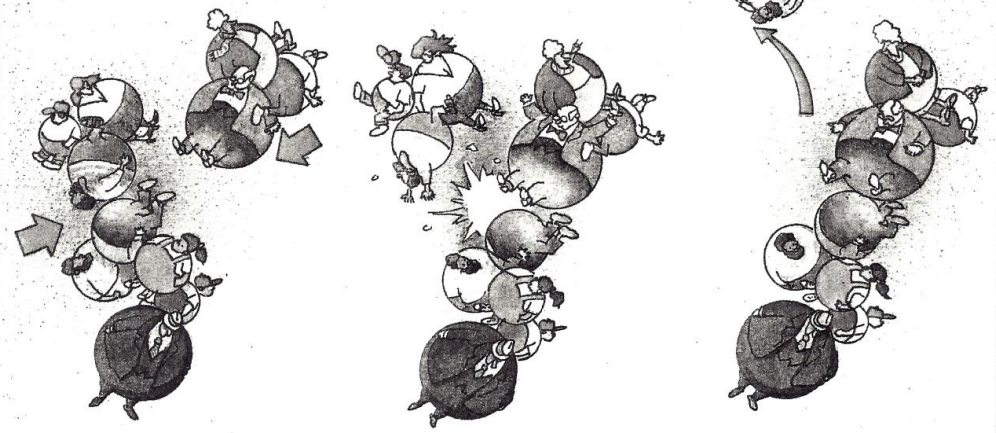
Cells need to be able to break bonds to rearrange molecules in all sorts of ways and to dispose of molecules no longer needed.

Sometimes forceful collisions can break bonds apart.



The energy is released as heat.

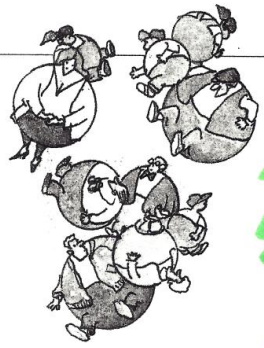
Energy Flows from One Bond into Another



A high-energy molecule is about to collide with the molecule approaching from the right.

If the collision occurs at the right place and at just the right angle, the key bond in the high-energy molecule will break...

...transferring energy to the new molecule and discarding the displaced atoms of the high-energy molecule.



Life is possible because of the great variety of molecular combinations. Using mostly carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulfur, life fashions all its simple molecules and a near-infinite variety of large chain molecules.

Transferring Energy

Specific "key" bonds in certain kinds of molecules can produce an unusual amount of energy. When these high-energy bonds are broken, a substantial part of the energy in them can be *transferred* to other molecules, instead of all being lost as heat. That energy is captured and preserved in a new bond between part of the high-energy molecule and the new molecule to which the energy has been transferred. All the important activities of cells, such as constructing and moving, are carried out by large molecules of protein.

Proteins, the worker molecules of life, manage energy through this kind of transfer. Every time a bird flaps a wing, a maple tree sprouts a branch, or a clam opens its shell, bond energy is being transferred. Everything that happens in living cells is the result of various combinations of bond-breaking, bond-making, and energy transfer.

Artifact 4.2

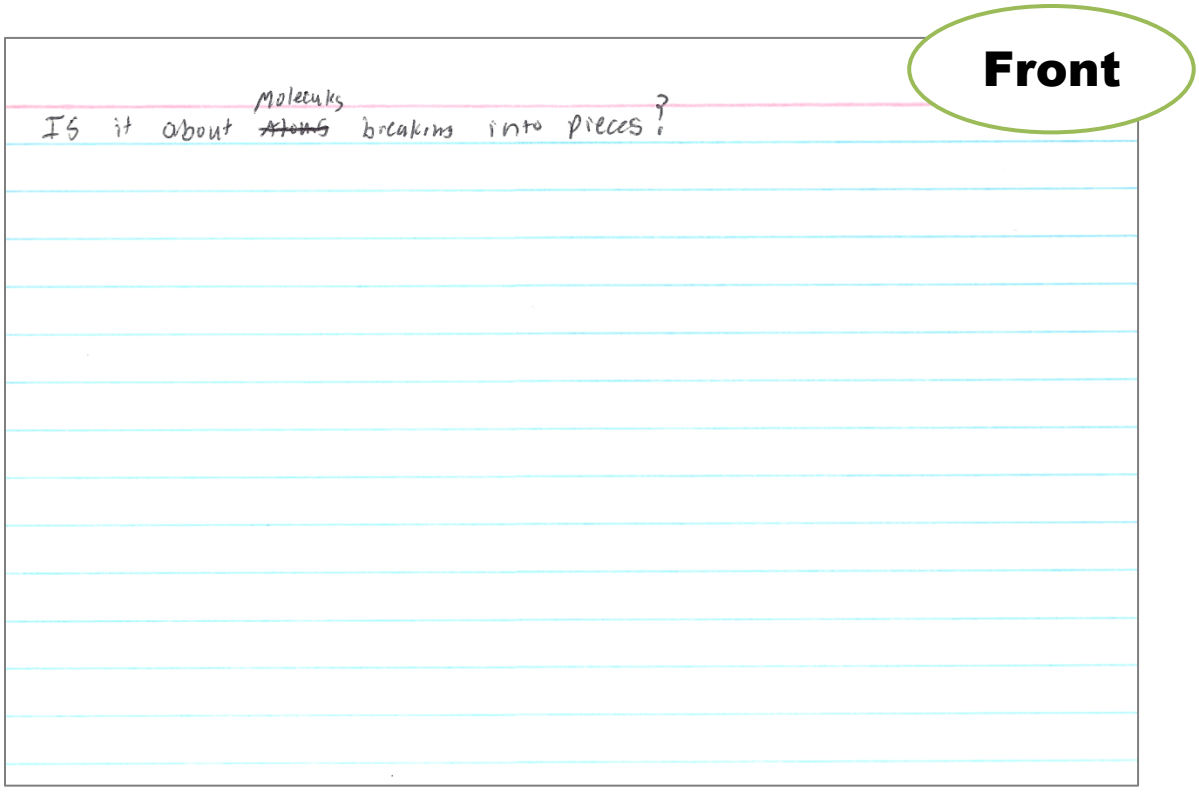
Front

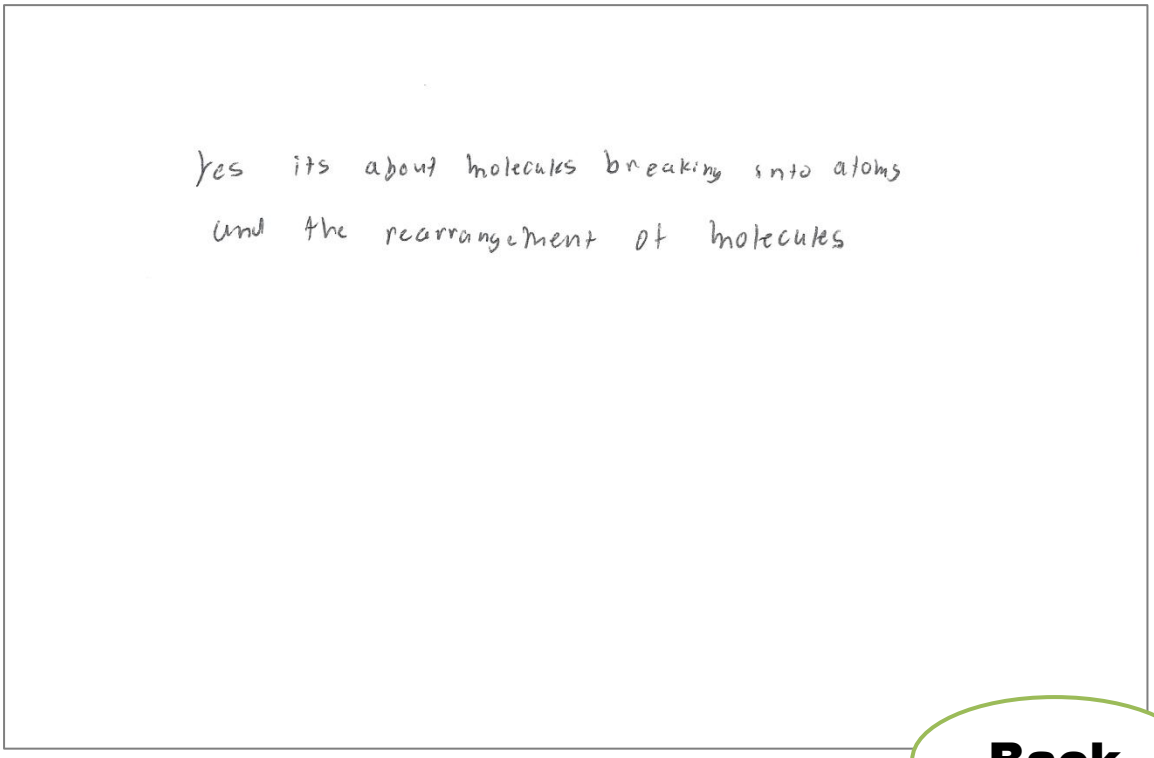
Is it about molecules changing?

Yes it's about them going from a type of bond to an atom by breaking apart.

Back

Artifact 4.3


Front
Is it about ~~Atoms~~ Molecules breaking into pieces?


Yes its about molecules breaking into atoms
and the rearrangement of molecules
Back

Artifact 4.4

Front

How energy transfered?

Energy is transferred by transferring into other molecules, constructing and moving molecules.

Back

Artifact 4.5

Quick Write

Section 3.2
Molecular Changes

Briefly explain how energy is transferred from one molecule to another.

Energy is transffered by moving from one molecule to another, energy transfer, or by making or constructing new molecules. This can happen every time a bird flaps its wing, a cloth opens its mouth, or a tree makes a new branch.

Artifact 5.1

It seems strange that in a universe where matter and energy disperse — "run downhill" — life congregates and organizes — "runs uphill." This contradiction, symbolized at the right, is more apparent than real, as we explain on page 94.

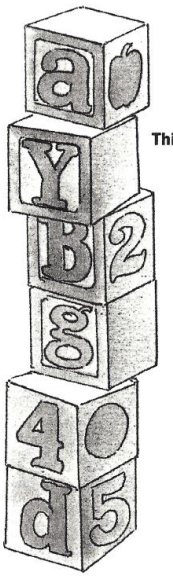
3.3 Life and the Laws of Energy

Running Uphill in a Downhill Universe

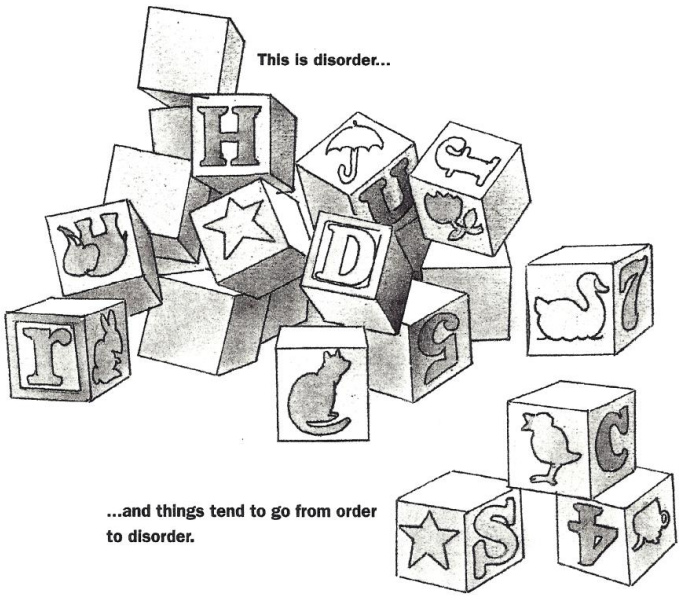
Incredibly, all the chemical processes of life and, indeed, all the energy and matter in the universe obey two simple laws: the *laws of thermodynamics*. The first law says that energy can be gained or lost in chemical processes — shifted from one form to another — but it can't be created or destroyed. Income and expenditure of energy have to balance. The second law says that energy inevitably disperses, dissipates, scatters — that is, it is transformed from more usable forms such as photons and bonds to a less usable form, namely heat. The tendency of energy to disperse and of ordered structures to become disordered, is called entropy, and physicists say that the entropy of the universe is increasing.

And this brings up a puzzle. If the universe is dispersing its energy, if things are generally running down, how is it that life seems to be going the other way? Paradoxically, while energy has been spreading out, life appears to have gotten increasingly more ordered and complex over time. How can life build uphill with energy that runs only downhill?

In considering this question, we begin with the basic truth that life never contravenes, outwits, or otherwise gets around the fundamental laws of nature. It simply finds ways of using those laws to its own advantage.

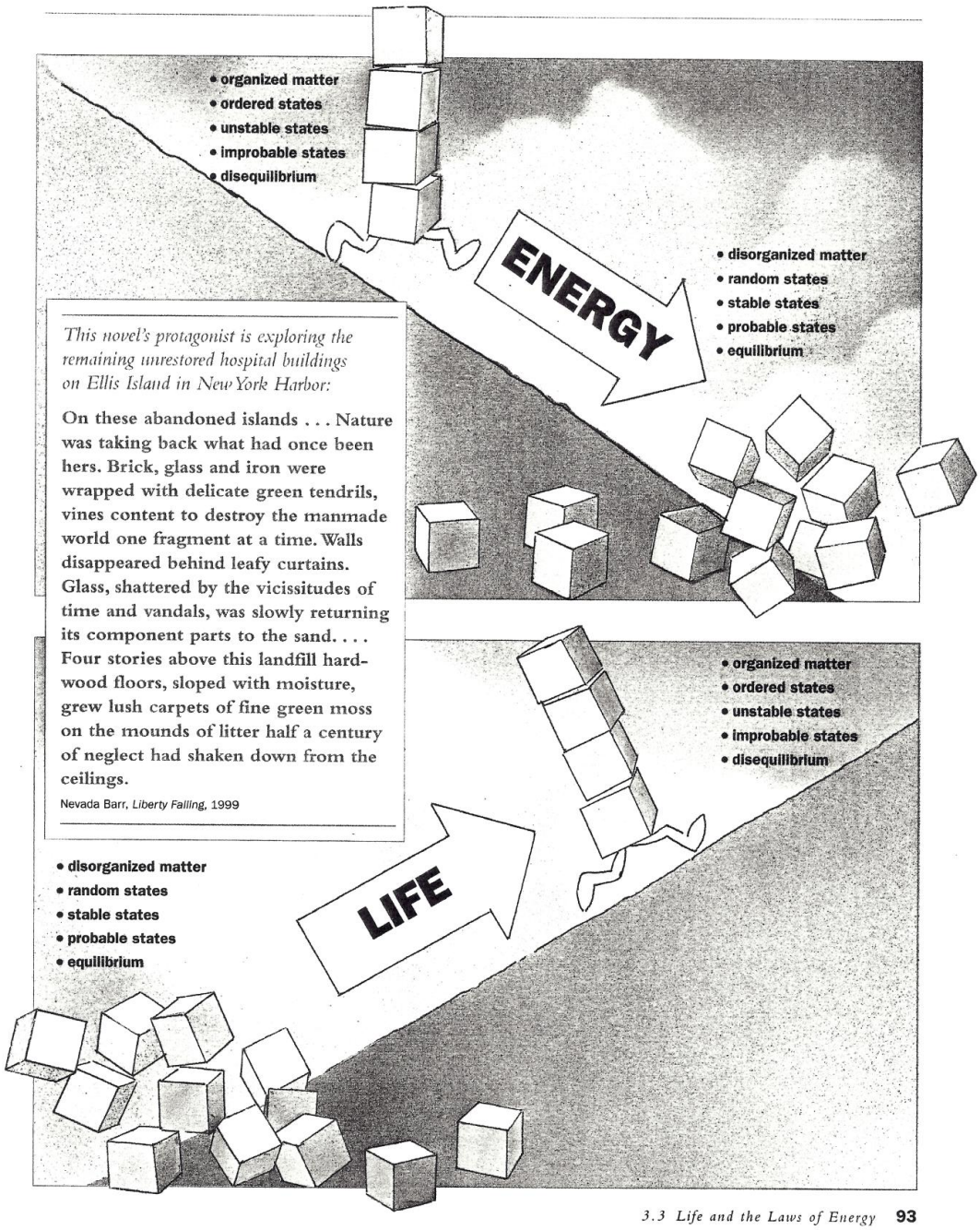


This is order.



This is disorder...

...and things tend to go from order to disorder.



This novel's protagonist is exploring the remaining unrestored hospital buildings on Ellis Island in New York Harbor:

On these abandoned islands . . . Nature was taking back what had once been hers. Brick, glass and iron were wrapped with delicate green tendrils, vines content to destroy the manmade world one fragment at a time. Walls disappeared behind leafy curtains. Glass, shattered by the vicissitudes of time and vandals, was slowly returning its component parts to the sand. . . . Four stories above this landfill hardwood floors, sloped with moisture, grew lush carpets of fine green moss on the mounds of litter half a century of neglect had shaken down from the ceilings.

Nevada Barr, *Liberty Falling*, 1999

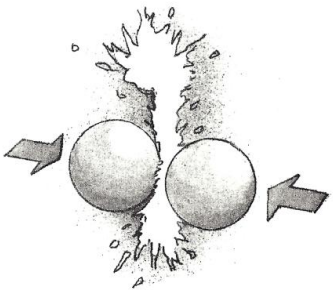
The Good News About the Second Law of Thermodynamics

Consider Earth's lucky circumstances. Our planet orbits just near enough to the Sun to take advantage of its unlimited, steady output of energy without becoming too hot for stable chemical bonds to form. A constant flow of energy, described by the second law of thermodynamics, keeps our planet in a comfortable yet energized state in which bond-making, bond-breaking, and energy transfers occur readily. Action and change occur as energy moves toward a more scattered state. The Sun's light and heat flow over the Earth and then on into the quiet and cold of outer space, where the temperature is near -273 °C — what scientists call absolute zero. At absolute zero, nothing can happen: nothing moves, nothing has direction, time itself stops.

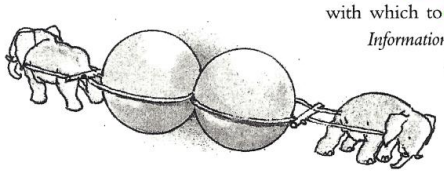
Let's take a close-up look at bond-making to see how this dynamic state of affairs works. Each time a bond connecting the simple atoms of life is created, some of the energy put into the bond is used to make it and some is dispersed into the surroundings as heat. In other words, more energy goes into making a bond than actually ends up *in* the bond; the excess is spread out into the surroundings. This seemingly wasteful dispersal of energy as heat, which is described by the second law of thermodynamics, has a beneficial effect. Think of it this way: If some of the bond-making energy didn't disperse but stayed nearby, it could readily flow right back and *unmake* the bond. The heat dispersal is necessary to ensure that what gets put together stays together — that, at least for a time, the building process is one way. The construction of bonds between atoms makes possible the creation of information (DNA). Information, in turn, brings order in its wake. Thus, as energy flows downhill, information accumulates, resulting in an uphill snowballing of complexity.

Thus, the second law of thermodynamics does not threaten life, but instead guarantees: (1) a steady stream of usable energy dispersed by the Sun, (2) stable molecules with which to build, and (3) the assembly of information chains (see Chapter 4, *Information*). Running uphill is a highly creative energy — and information — driven process that depends upon a dogged and persistent rebuilding at the molecular level (like the castle-building crabs at the right).

Some of the energy that goes into the making of the bond is scattered as heat.



This ensures that the bond will be stable enough for the construction work of life. Breaking the bond would require at least as much energy as it took to make it.

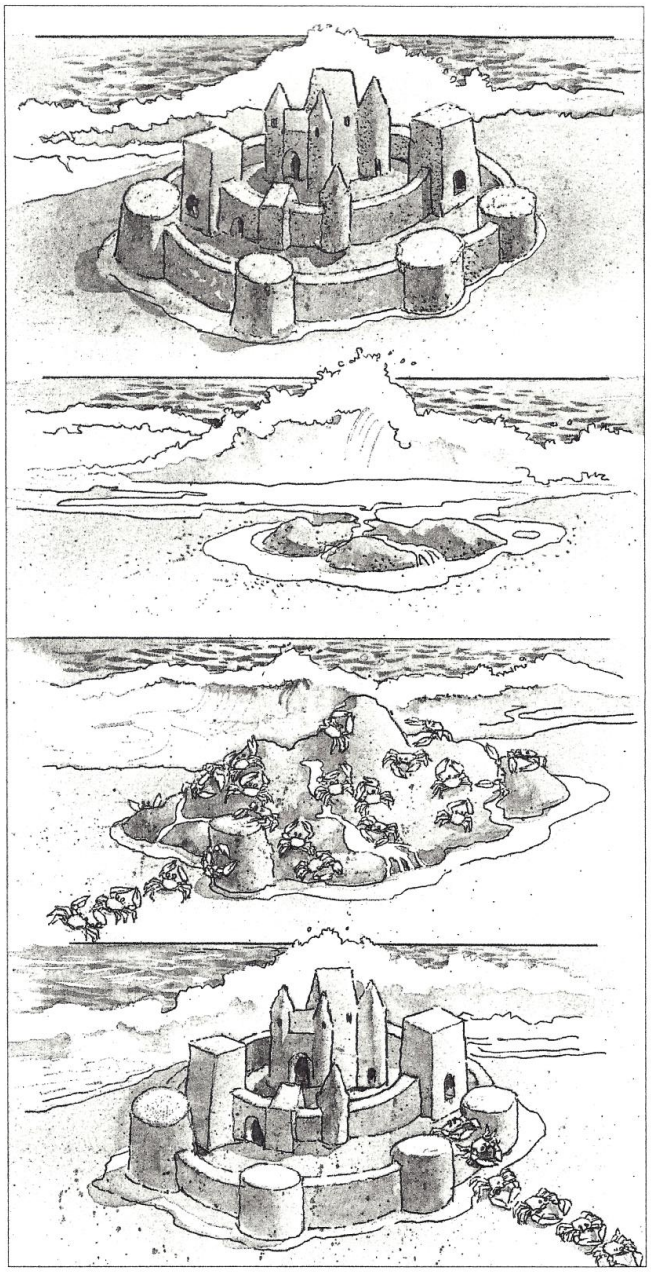


Question.

Why do cats frequently like to sit on the hood of a car that has just been driven for a while? How does this result of a car's fuel use parallel the energy transfer and dispersal during cellular respiration (burning of sugars)?

Answer...

When a car burns its fuel, it is breaking down the organized bonds of the molecules that make up gasoline, using some of the released energy (about 20%) to push the pistons of the engine up and down, and dispersing much of it (about 80%!) into the surroundings as random molecular movement (i.e., heat) that warms the engine block and the hood of the car but doesn't move the pistons. Cats take advantage of this heat source.



A Sand Castle Analogy

A sand castle is a vivid analogy for the effects of entropy. Inevitably, powerful natural forces — waves — will reduce the castle to the random disorder of the sand grains from which it arose.

In the inanimate world, what gets dispersed stays dispersed.

Life can neither circumvent nor otherwise escape the second law of thermodynamics, but it can, for a time, resist the tendency to disperse. Suppose, as a fanciful example, that after each wave, a colony of crabs rushes in and makes repairs so feverishly that the castle is completely restored before the next wave.

Of course, crabs don't actually behave this way, but in living systems, proteins perform the job of rebuilding. Their activities require a steady input of energy supplied by the Sun and then converted to high-energy bonds. In the animate world, what gets dispersed generally gets rebuilt.

Initially, cream molecules and coffee molecules are separate (as shown in the cutaway section).

Random movement and collisions begin to disperse the cream in a process called diffusion.

In time, the cream molecules will disperse throughout the coffee.

Energy Flow and Equilibrium

Life is a big bag of chemical reactions.

Imagine that you've shrunk to the size of a cell and can watch a chemical reaction take place. A cell is about to put together a bigger molecule out of some smaller molecules. We call the molecules (or atoms) present at the beginning of a chemical reaction *reactants* and the resulting atoms and molecules *products*. When we talk about chemical reactions, we're usually talking about millions of atoms in a confined space constantly rushing around and colliding with each other. The more atoms there are — the more people crowding Grand Central Station — the more collisions there'll be and, therefore, the more likely that chemical rearrangements will happen.

A chemical reaction starts with lots of reactants and no products. Within seconds, reactants get converted into products. As the products pile up, the reactions begin to slow down. Finally, when the energy stored in reactants and products is equalized, no further products accumulate. The atoms have not stopped reacting with each other, however. Collisions continue to convert reactants to products, but now an equal number of collisions convert products back into reactants. When the energy flows as readily backward as forward, no further overall change takes place. This state of affairs is called equilibrium. (The flea-bitten dogs at the right illustrate the principle.) Life generally abhors equilibrium, because that's when cells become inactive and die. By ceaselessly adding reactants and removing products, living cells maintain themselves in far-from-equilibrium conditions.

Question.

What might be the possible outcome if bonds break and re-form every time one atom or molecule collides with another? How can enzyme proteins help regulate reactivity?

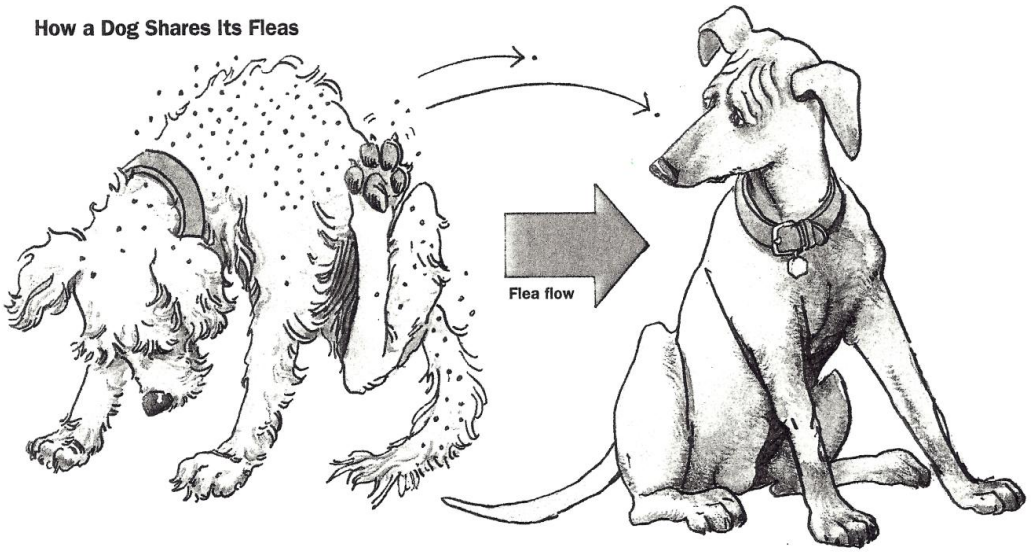
Answer...

Stability is an important property of all molecules, especially those on which life depends. If everything that could react did react, all living organisms and much of the non-living world would burn up instantly or at least exist in a very unstable environment where life would be impossible. Luckily, molecules are far enough away from one another in most cases and have insufficient energy to react spontaneously except in rare situations. For two molecules to react, a certain threshold amount of energy is needed to break existing bonds (and therefore allow new ones to form). Enzymes help insure both stability and reactivity by overcoming this energy threshold in a controlled way, thus promoting the union of cellular molecules of the right type, in the right place, and at the right time. This helps keep the cellular interior organized despite many random collisions of these same molecules.

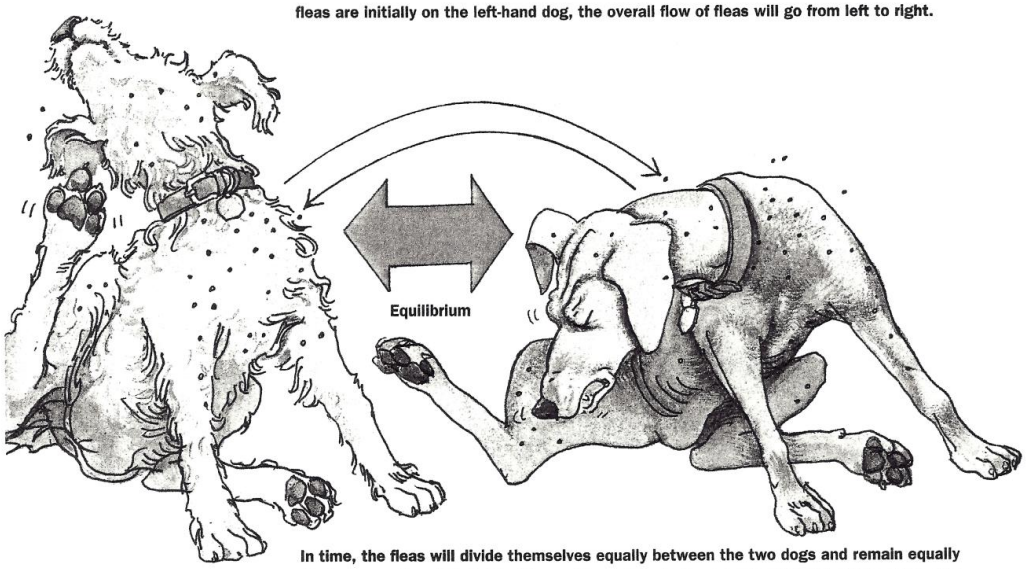
No need to stir in the cream

The second law of thermodynamics is illustrated by the tendency of cream to disperse in coffee. Once the cream molecules thoroughly disperse, they stay that way. The chance that they'll all float back to the surface is virtually zero. Even though they continue to move and bump into other molecules, they remain more or less evenly dispersed.

How a Dog Shares Its Fleas

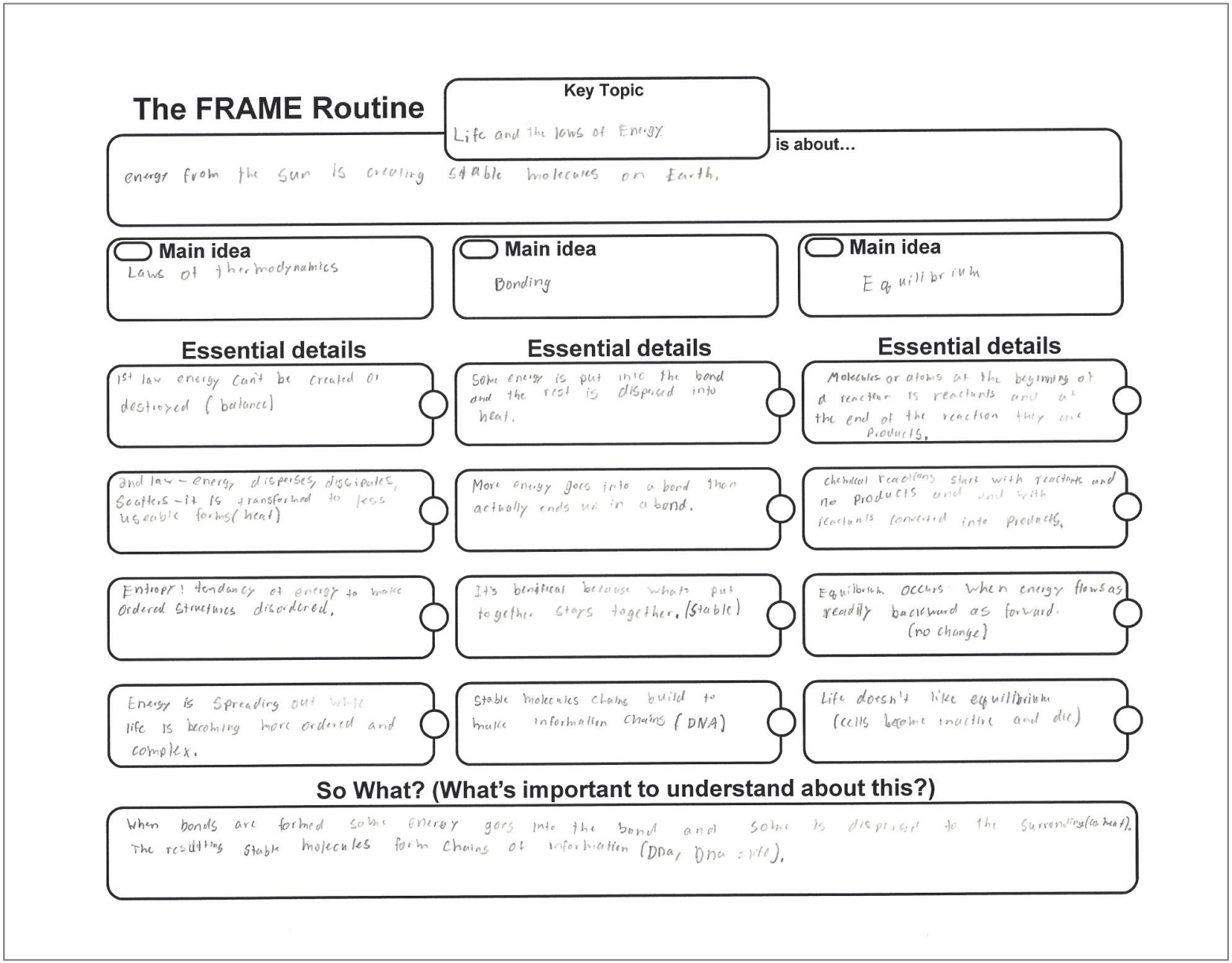


Assume the fleas will, with equal readiness, jump from one dog to another. If all of the fleas are initially on the left-hand dog, the overall flow of fleas will go from left to right.



In time, the fleas will divide themselves equally between the two dogs and remain equally divided even though individual fleas will continue to jump back and forth at the same rate as before. This is equilibrium. To keep the fleas flowingfrom left to right, we would have to put more fleas on the left dog or take fleas off the right dog.

Artifact 5.2



The FRAME Routine

Key Topic

Life and the laws of Energy

is about...

energy from the sun is creating stable molecules on Earth.

Main idea	Main idea	Main idea
Laws of thermodynamics	Bonding	Equilibrium
Essential details	**Essential details**	**Essential details**
1st law energy can't be created or destroyed (balance)	Some energy is put into the bond and the rest is dispersed into heat.	Molecules or atoms at the beginning of a reaction is reactants and at the end of the reaction they are products.
2nd law - energy disperses, dissipates, scatters - it is transformed to less useable forms (heat)	More energy goes into a bond than actually ends up in a bond.	chemical reactions start with reactants and no products and end with reactants converted into products.
Entropy: tendency of energy to make ordered structures disordered.	It's beneficial because what's put together stays together. (stable)	Equilibrium occurs when energy flows as readily backward as forward. (no change)
Energy is spreading out while life is becoming more ordered and complex.	Stable molecules chains build to make information chains (DNA)	Life doesn't like equilibrium (cells become inactive and die)

So What? (What's important to understand about this?)

When bonds are formed some energy goes into the bond and some is dispersed to the surroundings (as heat). The resulting stable molecules form chains of information (DNA, DNA cells).

Artifact 6.1

Reading Strategies Post Assessment

SQ3R

Did you find the "SQ3R" strategy useful? Why or why not?

Yes I was able to get the key information out of the reading easier.

What aspects or components of the "SQ3R" strategy did you like best? Least?

I liked asking the questions the most. I didn't like surveying or reciting.

Did using the "SQ3R" strategy help you better comprehend what you read? Explain.

yes it help me find the main points and get done easier.

When (in which situations) do you think the "SQ3R" strategy would be most useful?

When reading a textbook the SQ3R would be the most useful.

Do you think that you will use the "SQ3R" strategy on your own? Explain.

Yes it helped me get my work done easier and seems like it will help in the future.

The FRAME Routine

Did you find "The FRAME Routine" strategy useful? Why or why not?

yes it helped organize the information I read more easily.

What aspects or components of "The FRAME Routine" strategy did you like best? Least?

I liked being able to organize the key information and main points. I didn't like not being able to ask my own questions.

Did using "The FRAME Routine" strategy help you better comprehend what you read? Explain.

NO it just helped me organize the information easier.

When (in which situations) do you think "The FRAME Routine" strategy would be most useful?

when you have to write a paper on a book or article it would help organize the information so you could write your paper easier.

Do you think that you will use "The FRAME Routine" strategy on your own? Explain.

yes when I need to write an essay paper I will use it to organize the information I read.