# Teacher Overview Model B: Biosynthesis

**Transition in:** *The transition here is to now think about the matter from the food we eat. We know that not all of the food we eat is used for energy. What happens to the food not used for energy? What happens if we take in more food than we can use?*

**Overview**

We now switch to thinking about the matter from the food we eat and how it is involved in cellular respiration. We ask, is it used for anything else?  We quickly review relevant ideas from past models and readily recognize that the food we eat provides us with the components we need to build new body tissue.

 We also review some ideas about digestion—that it breaks food first into carbs, fats and protein molecules, and then into their monomers.  But now we explicitly discuss how some of our digested food is used to build new macromolecules and to repair existing or build new body tissue. We also figure out that the excess food that we take in is stored as fat. We then reason that our bodies can use fat for cellular respiration when we run out of glucose. Lastly, we recognize that building macromolecules requires energy or the “uphill” energy diagram. This is presented differently for the ethanol and electrolysis pathways, as this is the first time students who made sense of chemical reactions using ethanol have been exposed to the idea that some reactions require energy input. Just before we return to the Hibernating bear challenge question we discuss the idea of energy and matter cycles in organisms, tying several components of our Matter and Energy from Food models together.

 When we return to our challenge question we spend a bit of time making sure our ideas are consistent with our models. This is scaffolded by a Four Corners activity, several readings, review of key points from the Hibernating bear explanation, then continuing the explanation process through group writes, a gallery walk, group and a whole class discussions. You may want to use some or all of these activities depending on your students’ level of understanding. As their final assessment, students now answer the Hibernating bear Question individually using their class models.

**Transition out:** *We have fairly complete models for how we (and many other organisms) obtain matter and energy from food. But we have a number of lingering questions about plants? Do they eat food? How do they obtain matter and energy? We transition into our exploration of Photosynthesis at this point and ask a Challenge Question that is the reverse of the Hibernating bear: How does a seed grow into a tree? Where did the matter (and energy) come from?*

**Overall Time:** 3-6 days

**P-Q-M for Model B: Biosynthesis**

**Phenomenon:** We don't just use our inputs to get energy, we also use the "stuff" to make new biomolecules for repair, replacement and growth.

**Question:** How do we get matter from food? How do we make new carbohydrates, fats and proteins? What happens when we take in more food than our body can use? What happens to fat and protein when they enter the body and then when we exercise? Are carbohydrates the only fuel for energy? How do we store energy?

**Model:**

*As we move through the remainder of the Red Loop and develop ideas about matter and energy flow in organisms, we explicitly develop two models in parallel. In our work with Biosynthesis, we primarily add ideas to a model for Matter from Food. See Teacher Slides in the PowerPoint for details on how to track the models in the classroom.*

**Matter from Food (primary model here):**

Ideas from Our Model for Chemical Reactions

Matter is conserved, neither created nor destroyed. Matter is rearranged in chemical reactions.

Food has matter in the form of protein, carbs and fats- the same things we find our bodies are made of. We also take in matter as oxygen and water.

Some of this matter is used in our body, but we take in much more matter than we need to use to grow or maintain body structures.

Some of this matter (especially much of the water but also some indigestible material) basically passes through us.

Ideas Added in Cellular Respiration

Some of this matter is really taken in for energy. It is rearranged to obtain energy in a reaction called cellular respiration. The products are expelled from the body as carbon dioxide and water (CO2 + H2O).

**New Ideas in Biosynthesis**

Some of our digested food is used to build new macromolecules to repair and to build new body tissue

Food consumed in excess of what we need for energy and growth/repair is converted to fat and stored.

Building new biomolecules (proteins, fats and carbs) from the products of digestion requires energy

**Energy from Food (secondary model here):**

Ideas from Our Model for Chemical Reactions

Energy is conserved, neither created nor destroyed. Energy is transformed in chemical reactions.

When the reactants have more potential energy than the products, energy is released in the reaction (“downhill” reaction).

[electrolysis classrooms only]

When the products have more potential energy than the reactants, energy must be added to the reaction (“uphill” reaction).

**New Model Ideas** [Ethanol classrooms only]

When the products have more potential energy than the reactants, energy must be added to the reaction (“uphill” reaction).

Food has energy in the form of calories.

Living things get energy by rearranging food and oxygen molecules.

Ideas Added in Cellular Respiration

Living things rearrange food (specifically glucose - C6H12O﻿6﻿) and O2 into CO2 and H2O

(C6H12O6 + O2) have higher energy than (CO2 + H2O) so this rearrangement releases energy.

- The rearrangements occur in a series of steps rather than all at once.

- Collectively the reactions are called cellular respiration.

- Usable cellular energy is released in the form of ATP.

UNITY AND DIVERSITY: Other reactions (such as fermentation) can produce biologically usable energy, but they are usually less efficient. We see these reactions in some groups of organisms that have evolved under different environmental conditions and in our own bodies during times when oxygen is not readily available.

**New Model Ideas**

If you run out of glucose your body can pull from fat stores and then as a last resort, amino acids to provide fuel for cellular respiration

B Biosynthesis at a Glance (approximately 3-6 traditional class days):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Seg | Model Move | Est Time  (min) | Overview | Resources | What did we figure out? |
| 1 | **M🡪Q** | 15-20 | We now switch to thinking about the matter from the food we eat and how it is involved in cellular respiration. We ask, is it used for anything else? We quickly review relevant ideas from past models and reason that the food we eat provides us with the components we need to build new body tissue. | * CR Doodle Sheet * IOU Representation * B 02 Doodle Sheet * B 01 Doodle Digestion Diagram | We’ve explicitly shifted our focus to questions about how we use matter after two triangles of dealing with energy. And we have reviewed what happens to the matter once it enters our bodies. |
| 2 | **M🡪Q** | 15 | We now go deeper to try to understand what happens to the food we eat beyond what we need for energy, growth and maintenance. We then ask why would we store excess fat, what purpose does it serve? In this way we develop ideas around fat as an energy reserve so if you run out of glucose, then you can draw on your fat for fuel for cellular respiration. | * B Doodle Sheet * B 01 Doodle Digestion Diagram | We have figured out that when you take in excess food, it is stored as fat. We also reasoned that this fat provides an energy reserve if your glucose pool runs dry. Only as a last result would you draw from your amino acid pool for fuel. |
| 3 | **M🡪P** | 20-30 | We apply the chemical reaction model to the process of building new biomolecules in our cells.  Electrolysis Path: In classrooms that did electrolysis, this can be a simple conversation asking which reaction diagram makes sense for biosynthesis—the uphill reaction or the downhill reaction?  Burning Ethanol Path: In classrooms that have only considered energy-releasing reactions, we need to take some time to consider how energy might be involved in the synthesis of larger biomolecules. We do this in a paper activity by “building a protein” from amino acids to see that synthesis takes work. | * B 02 Doodle Sheet   Burning Ethanol Path will also need:   * B 03 Building a Protein TEACHER GUIDE * B 03 Amino Acids PDFs (multiple files) | We figured out that building biomolecules requires energy, as indicated in our “uphill” reaction diagram. The energy comes from chemical reactions such as cellular respiration. |
| 4 | **M** | 30 | Now that we recognize both occur in our cells, we pause for a moment to consider the pairing of energy-releasing and energy-requiring reactions in the body. We apply our models (Chemical Reactions, Energy from Food and Matter from Food) to the case of the coma patient in order to reinforce the idea of our bodies as matter and energy cycling machines. | * B 02 Doodle Sheet * Posted Chemical Reaction model * Posted Energy from Food Model * Posted Matter from Food Model | We now have some concept that energy “cycles” in organisms. These cycles keep us going at our bare minimum or maintain the basal metabolic rate. If we need to do more than just maintain our body, then we need more fuel. |
| 5 | **M🡪P** | 20-150 | Now we have the revised models we need to tackle the Hibernating Bear explanation. We work in groups to consider any new ideas and to evaluate our understanding. [This learning segment is heavily scaffolded and depending on your students you may wish to use all of it or very little]. | * CR Doodle Sheet * B Doodle Sheet * B 05 Hibernating bear Four Corners Handout and Materials   B 05 Hibernating bear Four Corners Readings | We hope to have a coherent explanation for the Hibernating Bear that includes two key points: (1) When we use more food than we eat our body begins breaking down stored fat for cellular respiration. (2) This reaction produces H2O (lost as sweat or urine) and CO2 which is exhaled. H2O input and output are equal, so the matter he lost is mostly converted to CO2. |
| 6 | **M🡪P** | 30 | We ask students to apply the models to explain how exercising helps a person lose weight. Then they use their model ideas of Energy from Food and Matter from Food to individually explain where the weight goes when someone loses weight. | * B 02 Doodle Sheet * B 06 Why Exercise Handout | Exercise helps with weight loss because exercise requires a lot of energy and the more energy we need, the more cellular respiration must happen to provide the energy. The more cell respiration, the more food (or fat when all food is used up, fat) is converted to CO2 and leaves the body when we exhale. Students have also figured out that when weight is lost matter is lost in the form of carbon dioxide that is breathed out. Their explanation is written in a complete, coherent model-based explanation using the models developed while making sense of the hibernating bear phenomenon. |
| 7 | **M🡪P** | 20 | We use our two big models, Energy from Food and Matter from Food, to individually write final explanations for the Hibernating Bear. This is the summative assessment. | * B 07 Hibernating Bear Challenge Handout * B 07 Hibernating Bear Challenge Rubric | We’ve figured out that when we lose weight, we lose matter in the form of carbon dioxide that we breathe out. The final product is a complete, coherent model-based written explanation for the Hibernating Bear (see rubric). |

## Learning Segments in Detail:

We recommend that you have the PowerPoint slides open while you review the details of this document.

## 1. **M🡪Q: We now switch to thinking about the matter from the food we eat and how it is involved in cellular respiration. We ask, is it used for anything else? We quickly review relevant ideas from past models and reason that the food we eat provides us with the components we need to build new body tissue.**

Estimated time: 15-20 min

Resources:

* CR Doodle Sheet
* IOU Representation
* B 02 Doodle Sheet
* B 01 Doodle Digestion Diagram

Details: The transition here is to recognize the relationship between energy from food and matter from food so we begin by asking what happens with the matter in cellular respiration? This conveniently leads us into a review about cellular respiration, focusing on the matter, that can be record on the doodles or not.

We are now focusing on the matter from food, so we review cellular respiration from a matter perspective. What matter is involved in this process?

The next few slides will aide in the review. These slides are animated so you can provide “think time” The answer to the review question will appear after the students have a chance to think and write on the Doodle. This is not about “taking notes,” this is about thinking and then comparing your ideas with other’s ideas.

The Doodle Sheet: Digestion Diagram is designed so your students can add to the diagram as we review and then add new ideas. Students may also respond to a writing prompt on the Doodle Sheet: How do we get matter from food?, or you can just have a verbal review. Either way you can use pair-shares to get the ideas out, or not –depending on how well students recall them.

The areas you’ll want to revisit are as follows:

* 1. Cell respiration: review reactants, products
  2. Go back to the inputs-outputs-uses (IOU) representation and review Uses. In the last model we focused on how we get ENERGY from our inputs, now we want to remind ourselves that we also get MATTER that we need for growth and repair of tissue.

We learned that digestion breaks food first into carbs, fats and protein molecules, and then into their monomers. We now ask students, once our food has been broken down, do we have all the substances we need to build new tissue? Students should remember that our bodies are made of proteins, fats and carbs, so of course the answer is YES.

**New idea: Some of our digested food is used to build new macromolecules to repair and to build new body tissue.**

**What did we figure out?**

We’ve explicitly shifted our focus to questions about how we use matter after two triangles of dealing with energy. And we have reviewed what happens to the matter once it enters our bodies.

## 2. **M🡪Q: We now go deeper to try to understand what happens to the food we eat beyond what we need for energy, growth and maintenance. We then ask why would we store excess fat, what purpose does it serve? In this way we develop ideas around fat as an energy reserve so if you run out of glucose, then you can draw on your fat for fuel for cellular respiration.**

Estimated time: 15 min

Resources:

* B 02 Doodle Sheet
* B 01 Doodle Digestion Diagram

Details: We know that the Hibernating bear originally gained weight by eating more food than he needed for energy, growth and maintenance. We now ask, what exactly happens to the food we eat beyond what we need? Once we learn it is stored as fat, we wonder what purpose that serves. We discover that if we use all our glucose, we will next pull from this fat storage. Effectively, fat is our stored energy! (Amino acids are only a last-resort fuel for respiration).

**What did we figure out?**

We have figured out that when you take in excess food, it is stored as fat. We also reasoned that this fat provides an energy reserve if your glucose pool runs dry. Only as a last result would you draw from your amino acid pool for fuel.

3. **M🡪P: We apply the chemical reaction model to the process of building new biomolecules in our cells**

### Estimated time: 20-30 min

Resources:

* B 02 Doodle Sheet

Burning Ethanol Path will also need:

* B 03 Building a Protein TEACHER GUIDE
* B 03 Amino Acids

Details: We now want to establish the nature of the energy change involved in biosynthesis reactions.

This move will continue to pay off in the next model when we discuss photosynthesis. We ask students to apply the chemical reaction model to the reactions that build new biomolecules in our bodies. Are they energy-releasing, or energy requiring reactions?

Electrolysis Path: We have a simple conversation and ask which reaction diagram makes sense for biosynthesis—the uphill reaction or the downhill reaction. (next 4 slides)

Burning Ethanol Path: For students who have only considered burning (and other energy-releasing reactions), we need to take some time to consider how energy might be involved in the synthesis of larger biomolecules. We do this in a paper activity by “building a protein” from amino acids to see that this takes work.

In either scenario, we do some work on the doodle sheets and then pair/share. We see that if these molecules release energy when we break them down, energy must be required to build them in the first place… or they may just intuit that building biomolecules is going to be an energy-requiring endeavor (as you might expect).

We consider the paired reaction diagrams and their implications in terms of:

ENERGY FROM FOOD – Really it makes sense that it takes energy to build proteins, fats, and carbohydrates because of the Law of Conservation of Energy. We know these large molecules contain a lot of energy that is released when we break them down. So it makes sense that to build those high-energy molecules in the first place we need to put in energy.

**What did we figure out?**

We figured out that building biomolecules requires energy, as indicated in our “uphill” reaction diagram. The energy comes from chemical reactions such as cellular respiration.

### 4. **M: Now that we recognize both occur in our cells, we pause for a moment to consider the pairing of energy-releasing and energy-requiring reactions in the body. We apply our models (Chemical Reactions, Energy from Food and Matter from Food) to the case of the coma patient in order to reinforce the idea of our bodies as matter and energy cycling machines**

Estimated time: 30 min

Resources:

* B 02 Doodle Sheet
* Posted Chemical Reaction model
* Posted Energy from Food Model
* Posted Matter from Food Model

Details: This is an opportunity for students to have a more in depth understanding of energy and matter cycles in the body and that the energy originally comes from the food we eat. We come back to the coma patient and use our three models of Chemical Reactions, Energy from Food and Matter from Food to explain why the man needs the feeding tube, and yet does not undergo a weight change. This segment is to help us understand cycling of matter in an organism and to continue our conversation about the paired uphill and downhill energy diagrams.

No matter what, even if one is in a coma, there must be an input of matter to provide the fuel for cellular respiration, for your basal metabolic rate, or the amount of energy your body needs for normal functions: brain activity, heart beating, breathing, all those things your body still does even when you are asleep. We now understand that the body can store fuel (glucose) long enough to keep you functioning while you are asleep but not if one is in a coma.

In the case of the coma patient he is given just enough food to maintain his basal metabolic rate. We were able to explain that he was given food and that he somehow rearranged the food from high energy molecules to low energy molecules and energy was released for his body to use for basic functions. We can now add that the fuel is used for cellular respiration to provide energy for basic functions and to help build any macromolecules he needs. He is not given anymore “food’ than his body needs, just enough fuel his body's cycles.

**What did we figure out?**

We now have some concept that energy “cycles” in organisms. These cycles keep us going at our bare minimum or maintain the basal metabolic rate. If we need to do more than just maintain our body, then we need more fuel.

### 5. **M🡪P: Now we have the revised models we need to tackle the Hibernating Bear explanation. We work in groups to consider any new ideas and to evaluate our understanding. [This learning segment is heavily scaffolded and depending on your students you may wish to use all of it or very little].**

Estimated time: 20-150 min

Resources:

* *CR Doodle Sheet*
* B 02 Doodle Sheet
* Hibernating bear 4 Corners Handout
* Sign with the names of each of the 4 Friends. Post one in each corner of the room.
* Hibernating bear 4 Corners Readings (as needed): (1) Matter and Energy, (2) What is Poop?

(3) How is water involved in organisms? (4) Food: What is it?

Details: We have the revised models we need to tackle the Hibernating bear explanation. We share the main points from their Hibernating bear explanations (CR Doodle U) and any unanswered questions from CR Doodle V. We take a quick look and make any quick revisions because it’s been a while since these key points were generated! Revise the key points as needed, but there is no need to spend too much time here as there are still more options to revise.

To solidify students’ command of the model, and expose any incorrect ideas, we do the 4 corners activity. Prior to the activity make signs with the names of the 4 friends and hang them in the 4 corners of your room. Take the class through these steps:

1. Students write the name of the friend they agree with and on the back of the paper they explain why they agree with that friend **AND** they also explain why they disagree with the others.
2. Once all are ready, they each go to the corner of the person they agree with. If everyone winds up in Demarcus’ corner then you can have a brief discussion, pat them on the back, and move on. But if there are students in different corners, instruct each group to discuss why they chose that corner, and pick a spokesperson who will explain their position to the class.
3. Spokespersons take turns explaining. Once each group has explained its position, allow them to cross-talk. They can try to convince other groups of their position and/or ask questions of other groups.
4. Now ask if anyone wants to change corners.
5. If all the students are in Demarcus’s Corner and you feel confident that they can all explain in detail what happens to the matter, then you may want to give the summative assessment in Learning Segment 07
6. If there are students who are still challenged by this idea (those that are not in Demarcus's Corner) assign readings appropriately. You can approach this by saying that we are still unsure, so would you like more information. For students who are in Andy’s Corner assign the Water and organisms reading. Those in Jasmine’s Corner assign the Matter and Energy reading. Those in Isabella’s Corner assign the What is Poop? reading. Those in Demarcus’s Corner can confirm what they are already thinking with the FOOD reading.
7. We now read different texts to help us better understand which friend has made the best statement. We use the paired reading strategy to help access this information.

Students will return to the corner they were in before the reading.

1. Once all are ready, they will discuss what they have learned.
2. Now ask if anyone wants to change corners.
3. If needed because there are students in different corners, instruct each group to discuss why they chose that corner, and pick a spokesperson who will explain their position to the class.
4. Spokespersons take turns explaining. Once each group has explained its position, allow them to cross-talk. They can try to convince other groups of their position and/or ask questions of other groups.
5. Hopefully all students will shortly end up in Demarcus’s Corner. If not – in the next activity we ask students to directly map their key point to their models.

Next, we use the models and information from the texts, to revisit our class’ Key Points from the Hibernating Bear Explanation and ask groups to reflect on them now that we have more information. Each group discusses and creates a list of items that should be removed, added, or modified, a justification for each suggested change and how it is supported by a model statement. Then we come together as a class to finalize our key points that will help us with our explanation for the Hibernating bear. When all key points are represented and agreed upon, we record the key points on the Doodle Sheet.

Now we can individually answer the Hibernating bear question on the Doodle Sheet. We have structured this writing task using a Communication Triangle (see MBER Essentials) putting the student in the role of expert: they are to explain this phenomenon to their grandmother.

Groups then share and work together to write “best” answers on their whiteboards. This followed with a Gallery Walk.

We end this segment with a chance for the whole class to discuss the group explanations and any lingering questions they may still have form CR Doodle Box V. The goal is to prepare every student to write a detailed, model-based explanation of the Hibernating bear on their own.

**What did we figure out?**

We hope to have a coherent explanation for the Hibernating Bear that includes two key points: (1) When we use more food than we eat our body begins breaking down stored fat for cellular respiration. (2) This reaction produces H2O (lost as sweat or urine) and CO2 which is exhaled. H2O input and output are equal, so the matter he lost is mostly converted to CO2.

**6. M🡪P: We ask students to apply the models to explain how exercising helps a person lose weight. Then they use their model ideas of Energy from Food and Matter from Food to individually explain where the weight goes when someone loses weight.**

### Estimated time: 30 min

Resources:

* B 02 Doodle Sheet
* B 06 Why Exercise Handout

Details: As a check for understanding, ask students to apply the final model to explain how doing a lot of exercise helps the Hibernating bear contestants lose more weight. You can use the Ticket-out-the-Door handout, or pair/share and share out, but this should (hopefully!) go quickly.

**What did we figure out?**

Exercise helps with weight loss because exercise requires a lot of energy and the more energy we need, the more cellular respiration must happen to provide the energy. The more cell respiration, the more food (or fat when all food is used up, fat) is converted to CO2 and leaves the body when we exhale. Students have also figured out that when weight is lost matter is lost in the form of carbon dioxide that is breathed out. Their explanation is written in a complete, coherent model-based explanation using the models developed while making sense of the hibernating bear phenomenon.

**7. M🡪P: We use our two big models, Energy from Food and Matter from Food to individually write final explanations for the Hibernating bear. This is the summative assessment.**

Estimated time: 20 min

Resources:

* B 07 Hibernating bear Challenge Handout
* B 07 Hibernating bear Challenge Rubric

Details: Students write their final explanations individually. The only part of their notes we allow them to use is the model developed by the class. This is the summative assessment and is the first piece in this lesson sequence that we grade for quality and correctness.

**What did we figure out?**

We’ve figured out that when we lose weight, we lose matter in the form of carbon dioxide that we breathe out. The final product is a complete, coherent model-based written explanation for the Hibernating Bear (see rubric).