**Ocean Acidification Module**

Lesson Flow:

1. **Introduction (20 mins)**
   1. Split the students into groups, have them introduce themselves.
   2. Students list three acidic things and three non-acidic things in their kitchen, as a group.
   3. Bring together answers (suggest some if needed)
   4. Give examples of why acidity matters (how does acidity in the atmosphere and ocean affect our lives)
   5. Give big picture of the lesson: what will be covered, what will they learn:
      1. What is acidity?
      2. How do we measure it?
      3. What is ocean acidification?
      4. What is its effect on wildlife?
      5. What can we do to curb it?
2. **Shell experiment set-up (15 mins)**
   1. Safety talk! Good laboratory practices
   2. In groups, follow steps 1-X on the worksheet (to be prepared - item in italics will eventually be on the worksheet)
      1. *Fill cups with water*
      2. *Measure different amounts of citric powder*
      3. *Dissolve each amount of powder into a separate cup (be sure to identify which is which)*
      4. *Stir well*
      5. *Weigh each shell*
      6. *Put a shell in each cup (be sure to identify which shell was put into which cup)*
3. **pH definition and measurement (30 mins)**
   1. Students make hypothesis as to which solutions are more acidic (on your worksheet)
   2. Define pH, how to measure it (pH-meter vs pH paper)
   3. Students measure a range of solutions: vinegar, lemon juice, milk, tap water, limewater, baking soda, etc
      1. *Dip a strip of pH paper in each solution*
      2. *Read off the pH by looking at the colour scale*
      3. *Rank solutions on a pH scale*
   4. Talk about their ranked solutions and also more acidic/basic ones, show a wider range of pHs on a chart (battery acid, etc.)
   5. Introduce H+ to older students
   6. Students study the effect of dilution using lemon juice and bleach
      1. *Add more water*
      2. *Measure pH*
      3. *Teacher talks about scientific process: how many data points needed?*
      4. *Repeat the dilution once again*
4. **Ocean acidification (30 mins)**
   1. Introduce concept: curves of CO2 concentration in atmosphere, acidity of oceans
   2. Students think about it: where does CO2 come from (list sources), where does it go into (list sinks), what effects could this have on the oceans
   3. CO2 dissolution experiment
      1. *Have the students measure pH of tap/DI water with their more precise pH strips*
      2. *Have them bubble air into their water for some time with straw*
      3. *Re-measure pH*
5. **Interpret shell experiment (30 mins)**
   1. Follow steps from the worksheet:
      1. *Measure the pH of different solutions made at the beginning*
      2. *What results do you expect for each sample*
      3. *Weigh shells*
      4. *Calculate the difference in weights now/weights at the start*
      5. *Ask what they think this means for animals who live in these shells in the ocean*
      6. *Why did we use a solution with plain water?*
6. **Remedies to acidification (20 mins)**
   1. Students think of a way to curb ocean acidification, share some with the class
   2. Limewater experiment
      1. *Measure pH of a fresh lemon juice (or something acidic) solution*
      2. *Add some limewater to it*
      3. *Measure pH again*
      4. *Propose an explanation, how would you test it?*
   3. Talk about how this has been done in some lakes, but it isn’t a scalable solution, only reducing CO2 emission is
7. **Clean up (5 mins)**

Professional Development:

1. **Introduction**
   1. Why concrete experiments to teach abstract concepts?
      1. Foster exploration
      2. Reinforce concepts through tangible actions
      3. Engage students with different learning experiences
   2. Limited resources prevent large-scale experiments
   3. The approach taken at MIT in 3.091: mini hands-on take-home experiments
2. **The “goodie bags”** 
   1. Example: the ocean acidification GB
   2. What we’ve learnt
      1. Needs to be explicitly tied to graded assignments
      2. Bonus points aren’t a good enough motivation
      3. Connection to learning needs to be obvious, otherwise only partially done
      4. Always received with excitement
3. **Develop your own**
   1. Split into groups (based on discipline?)
   2. Think of new ways to make the learning tangible to the students, be sure to draw from the learnings from previous experiences
   3. Pick a specific lesson taught in your classroom, devise a hands-on activity and accompanying questions
   4. Present to the rest of the teachers

## **Ocean Acidification Overview and Learning Objectives**

1. Students will be able to (SWBAT) relate the concept of acidity to their everyday life experience.
2. SWBAT discuss the consequences of ocean acidification
3. SWBAT measure the effects of ocean acidification on ocean life

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| Activity | Time | Obj. | Goal |
| Split the students into their groups, do introductions | 5 | (1)  (2) | Split the class into groups of 2-3 students  Have the students say their name, where they’re from, and a fun fact about themselves |
| Set up experiment | 15 | (1)  (2) | Safety talk  Set-up procedure from worksheet |
| Discuss what acidity is,  Introduce goal and big concepts. | 15 | (1)  (2)    (3) | Warm up. Get students to think about acidity from their own experience.  Together, each group should make a list of three acidic things and three non-acidic things in their kitchen  Bring together answers in the big group. |
| Teacher introduces acidity | 10 | (1)  (2) | Give a big picture of the lesson and what will be covered  What is acidity, what is ocean acidification, etc. |
| pH lesson/ experiment | 30 | (1)  (2) | Define pH  Hypothesize and then measure pHs of different substances |
| Run with Fitbit/iPhone | 30 | (2)  (3) | Students can estimate how to energy they spend during activities to fill in energy map |
| Meditation | 10 | (2) | Students learn about Basal Metabolic Rate in their body |
| Balance Energy Map | 10 | (2) | Always using energy (even in sleep). Unbalanced sheet → student explores possible answers (basal metabolic rate |
| \*Hack your snack\* | 30 | (1)  (2)  (3) | (1) Students come up with their ideal, indulgent snack. (2) Calculate calories and figure out how to burn all those calories (3) Share with the class |

### **Experiment set-up (20 minutes)**

* + 1. Fill cups with water
    2. Measure different amounts of citric powder
    3. Dissolve each amount of powder into a separate cup (be sure to identify which is which)
    4. Stir well
    5. Weigh each shell
    6. Put a shell in each cup (be sure to identify which shell was put into which cup)

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### **Do now: Discuss “What is acidity?” (20 minutes)**

Instructions 2 minutes

Writing down ideas 3 minutes

Synthesizing ideas together 5 minutes

Introduce module goal 5 minutes

Time for questions 5 minutes

**Required materials**

* Some place to write down students’ ideas (White board etc)
* Paper and pencils for the students

**Instructions**

*Writing down ideas about acidity*

Introduce yourself by name and explain the goal of the module is to discuss acidity. Ask students to, in their groups, the students should discuss and make a list of three items in their kitchens that are acidic (lemons, grapefruits, pineapples) and three items that are basic ()

Possible talking through - Great! We are curious about those ideas! So now let's think about energy in two categories: energy that is stored and energy that is used [write down "energy stored" and "energy used" on the board]. Now let's go back to the ideas we thought about earlier. [go through the things written on the board and categorize them as stored or used]. Can you think of more ideas that can go under energy stored? [write them down] Can you think of more ideas that can go under energy used? [write them down] This looks awesome! So today in talking about energy, we are going to discuss the energy of our bodies. [Say this if food was not mentioned already] Similar to [use an example that a student came up with], our body also gathers and uses energy. What is this energy known to us as? [ask students to raise hands and give answers] Food! And how can we know how much energy is in a specific food item? [ask students to raise hands and give answers] In the same way that we say inches to measure length or pounds to measure weight, we use calories to measure how much energy is in a food. So that's on the "energy stored" side, and what goes on the "energy used" side? [ask students to raise hands and give answers] Some things on this side include: your BMR which stands for Basal Metabolic Rate, which is the energy used to do things like blink, breathe, and make your heart beat, digest, and grow.

So our goal by the end of this lesson is for all of you to have a better understanding of how food in the form of energy is stored and used in the body, and to do that we are going to do several activities today

*Synthesizing students’ ideas and introducing big energy concepts*

Explain that we are going to explore energy today - specifically, the energy that we gather and use to power our bodies through the day. At the end of the day, we want you to be familiar with a few important ideas about energy, and to understand how these connect to food so you can make informed choices about food.

### **Food as Fuel - The big ideas**

Instructions:

*Give students the big picture of the lesson;* Here are the big ideas we are going to cover today.

**Big idea #1: Action energy is called kinetic energy** - We had lots of ideas about action energy. When scientists and engineers talk about moving energy they call it kinetic energy. Today we are going to experience kinetic energy when we do exercise in the afternoon.

**Big idea #2: Stored energy is called potential energy**. Potential energy is stored energy for us to use later on. This morning we will eat a snack. The energy that we get from that snack will be stored by our bodies and we will use it in the afternoon for action!

**Big idea #3: Energy is transformed from one form to another.** We don’t create or destroy energy - all energy gets changed into different forms. Not all of the potential energy in the food we digest is used for activity or stored for later - some of it is given off as heat energy. But it does not disappear - it just gets changed into a different form.

**Big idea #4: Energy in is energy out.**  We don’t create or destroy energy - all energy gets changed into different forms. Not all of the chemical energy we digest is used for activity or stored for later - some of it is given off as heat energy. But it does not disappear - it just gets changed into a different form.

Resources: [Types of energy](https://www.enwin.com/kids/electricity/types_of_energy.cfm)