# TEACHER NOTES: Energy Crisis - A Student Athlete's Journey

## 5-Day Lesson Sequence for Grade 11-12 Biology

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## OVERVIEW & LEARNING GOALS

**Unit Learning Goal:** Students will understand how cellular respiration (aerobic and anaerobic) provides energy for athletic performance and explain how metabolic knowledge directly improves training and race outcomes.

**Success Criteria:** By the end of the week, students will:

- I can explain the differences between aerobic and anaerobic respiration and their ATP yield
- I can interpret physiological data (tables, graphs) related to lactate levels, oxygen consumption, and heart rate
- I can correct misconceptions about lactate and muscle acidosis
- I can apply metabolic knowledge to design training programs and nutrition strategies
- I can analyze why structured training produces better athletic outcomes than random training

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## DAY 1: STORY & BIG IDEAS

**Duration:** 1 class period (50-60 minutes)
**Bloom's Levels:** Remember (Level 1) → Understand (Level 2) → Predict (Level 3)

### Activity Flow

*Opening Hook (5 minutes)*

**HITS Used:** Questioning

- **Teacher-led discussion:** "Think-Pair-Share" protocol
  - Individual reflection (Think): "Tell me about a time you felt like 'hitting the wall' — in sports, exercise, or even during a tough exam. What did it feel like?"
  - Pair conversation (Pair): Students discuss with a partner (2-3 minutes)
  - Whole class share (Share): Volunteers share out; teacher charts responses on whiteboard
  - Teacher frames: "Today we're going to discover what's actually happening at the cellular level during these moments"

**Why this works:** Activates prior knowledge and makes the lesson personally relevant.
**Inquiry skill developed:** Observing and questioning personal experiences.

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*Part I Reading: The Problem (10 minutes)*

**HITS Used:** Small Group Learning + Explicit Vocabulary Instruction

- **Reading strategy:** Option for differentiation:
  - **Struggling readers:** Assigned partner read-aloud (pairs take turns, 2-3 paragraphs each)
  - **On-level readers:** Independent or partner read
  - **Advanced readers:** Read independently, then annotate key science concepts
- **Literacy integration:** As students read, teacher circulates with questions:
  - "What's Maya's problem?" (literal comprehension)
  - "Why do you think Kai explains this is a cellular issue, not a weakness?" (inference)
- **Explicit Vocabulary Introduction** (concurrent with reading):
  - Teacher identifies Tier 2 vocabulary words emerging in text:
    - **ATP** (energy currency) — show brief analogy: "ATP is like money for your cells"
    - **Cellular respiration** — break apart: "respiration" = breathing/breaking down, "cellular" = at the cell level

- **Glycolysis, pyruvate** — write these on board but note they'll explore depth later
  - Students keep a vocabulary log (can be individual or shared class chart)

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*Part II Email: Cellular Respiration Basics (15 minutes)*

**HITS Used:** Direct Instruction + Scaffolding + Think-Pair-Share

**Teacher Direct Instruction (7 minutes):**

- Teacher uses whiteboard or document camera to work through Kai's email alongside the class
- **"I do" phase (modeling):** Teacher reads aloud, drawing a **simple flow diagram** on the board as they go:

```
AEROBIC (with oxygen):
Glucose → Pyruvate → Krebs Cycle → ETC → ~32 ATP ✓ Slow but efficient

ANAEROBIC (no O₂):
Glucose → Pyruvate → Lactate → 2 ATP ✗ Fast but inefficient
```

- Teacher think-aloud: "Notice how aerobic makes WAY more ATP. But anaerobic is faster—sometimes your body needs quick energy even if it's not efficient. That's like using a credit card vs. cash—different strategies for different situations."

**"We do" phase (guided practice) — Think-Pair-Share (8 minutes):**

- **Think (2 min):** Students individually answer:
  - "What are the two types of respiration?"
  - "Which makes more ATP? Why would that matter?"
- **Pair (3 min):** Students explain answers to a partner
- **Share (3 min):** Teacher calls on pairs to share; listens for key concepts, corrects misconceptions

**Literacy Connection:** Teacher uses student language to validate and expand: "You said 'aerobic needs air'—yes! And the reason it makes more ATP is because oxygen allows the cell to completely break down glucose. Anaerobic just starts the process."

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*Optional Mini-Lesson: Cellular Respiration Quick Recap (if needed) (5 minutes)*

**HITS Used:** Explicit Teaching + Scaffolding

**For students who are rusty on SBI3U content:**

- Quick 5-min flow diagram recap (no more detail needed yet):
  - **Location matters:** Glycolysis happens in cytoplasm (2 ATP), Krebs + ETC in mitochondria (30 ATP)

- **Oxygen is the key:** With oxygen → complete breakdown. Without oxygen → incomplete
- Tell students: "We're going to dig into the DATA on Thursday (Part III), so don't stress about every detail now"

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*Part II Questions - Individual Whiteboard Work (10 minutes)*

**HITS Used:** Questioning + Metacognition + Targeted Instruction

Students work on Part II questions at their desks. **Use individual whiteboards** (small dry-erase boards):

- Distribute individual whiteboards to each student
- **Question 1 (Understand):** "In your own words, explain the difference between aerobic and anaerobic respiration"
  - Students write answer on whiteboard, hold up
  - Teacher scans for misunderstandings in real time
  - If most get it: move on. If many struggle: spend 1-2 min clarifying as a group
- **Question 2 (Understand):** "Why does aerobic respiration produce more ATP?"
  - Same whiteboard protocol
- **Questions 2-3 (Analyze, Predict):** Students answer on paper
  - Partner share to check understanding
  - Teacher circulates to **provide descriptive feedback** (HITS):
    - "I see you said anaerobic is an advantage because it's faster. Yes! Can you also explain WHY someone would need quick energy even if it wastes glucose?"

**Numeracy Skill Developed:** Comparing ratios (32 ATP vs. 2 ATP — how many times more? This plants a seed for Friday's calculations)

**Inquiry Skill Developed:** Making predictions based on biological logic

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*Exit Ticket (5 minutes)*

**HITS Used:** Descriptive Feedback + Metacognition

Students respond on a slip of paper (formative assessment, informs Day 2 planning):

- "I felt confident explaining ___. I'd like more help with ___."
- Teacher collects; informs decisions about Day 2 direct instruction depth

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## DAY 2: DATA & ENERGY SYSTEMS

**Duration:** 1 class period (50-60 minutes)
**Bloom's Levels:** Understand (Level 2) → Analyze (Level 4)

### Activity Flow

*Warm-Up & Prior Knowledge (5 minutes)*

**HITS Used:** Questioning + Spaced Practice

- Quick recall: "Yesterday we learned two types of respiration. Turn to your neighbor and explain them in 30 seconds."
- Teacher poses: "If your muscles demanded 55 mL/kg/min of oxygen but your lungs could only supply 35 mL/kg/min, what would happen?"
  - (Sets up today's data work)

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*Direct Instruction: How to Read Graphs & Tables (10 minutes)*

**HITS Used:** Explicit Teaching + Scaffolding + Modeling

**Teacher Models (I do):**

- **Use a document camera or projected table from Part III**
- Teacher works through Table 1, row by row, with think-aloud:
  - "At rest, heart rate is 65 bpm. That makes sense—body is relaxed."
  - "During easy 2 km, heart rate jumps to 155. Why? Muscles are working, need more blood to carry oxygen."
  - "During intense 4 km, lactate spikes to 12.8 mmol/L. That's a BIG jump. This tells us Maya's aerobic system isn't keeping up."
- **Model graphing one data point:**
  - Project Figure 1 (lactate graph)
  - "Notice the x-axis is distance (0–6 km) and y-axis is lactate (mmol/L). The line shows lactate climbing steeply between 3–4 km. That's where Maya's aerobic supply couldn't keep up, so her body switched to anaerobic."

**Why this works:** Demonstrates what expert data readers notice (axes, trends, biological meaning). Students internalize this routine for independent work.

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*Small Group Learning: Table & Figure Analysis (20 minutes)*

**HITS Used:** Small Group Learning + Questioning + Scaffolding

**Teacher assigns flexible groups based on Day 1 exit ticket:**

- **Group A (Aerobic base builders):** Students who felt confident with respiration concepts. Task: "Study Figure 3 (Energy Systems by Duration). Which system dominates at 10 seconds? At 5 minutes? At 2 hours? Why does it shift?" Record observations on chart paper.
- **Group B (Lactate detectives):** Mixed-ability group. Task: "Use Table 1 & Figure 1. Find the moment Maya's lactate exceeded 4 mmol/L. What was her heart rate and oxygen consumption at that same moment?" Provides structured worksheet with guiding questions.
- **Group C (Advanced analysers):** Students ready for complexity. Task: "Compare Figure 2 (ATP yield) with Table 1. If Maya's anaerobic system produces only 2 ATP per glucose, calculate how much glucose she'd need to break down to match one glucose molecule in aerobic respiration." [Calculation: 32 ÷ 2 = 16 glucose molecules needed]

**Group Work Structure (HITS: Small Group Learning):**

- Assign roles: Scribe (records), Reader (reads questions aloud), Organizer (keeps group on task)
- Set clear norms: "Use the figures as evidence. Speak in complete sentences. Everyone contributes."
- Teacher rotates, providing descriptive feedback:
  - To Group A: "I see you identified that the phosphagen system drops off after 10 sec. Excellent! Now—what does that tell us about Maya's 6 km run? Which systems were at play?"
  - To Group B: "You found the right moment in the table. Now prove it using the figure. Where does the graph show lactate crossing 4?"
  - To Group C: "16 is correct! Can you explain what that means biologically? Why would Maya's body avoid this?"

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*Whole Class Sharing & Teacher Synthesis (10 minutes)*

**HITS Used:** Questioning + Descriptive Feedback

- Each group reports back (2 min per group)
- Teacher highlights connections:
  - "Group A identified phosphagen dominates at 10 seconds. Group C is calculating why that matters. Here's the link: **Phosphagen system gives instant ATP, but only for 10 sec. After that, anaerobic kicks in. After a few minutes, aerobic takes over.**"
  - Draws synthesizing diagram on board showing time progression

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*Part III Questions — Pairs or Small Group Collaboration (10 minutes)*

**HITS Used:** Small Group Learning + Questioning + Metacognition

**Question 1 (Data Interpretation):**

- Working in pairs, students locate the lactate threshold in Table 1
- Use whiteboard share: "At what distance did Maya cross 4 mmol/L lactate?"
- **Numeracy skill:** Reading data from a table; comparing numbers (12.8 vs. 4)

**Question 2 (Analysis):**

- "According to Figure 2, how many times MORE ATP does aerobic make?"
- Calculation: 32 ÷ 2 = 16 times
- Write on whiteboard: "16x more efficient"
- **Numeracy skill:** Division; interpreting relative magnitude

**Question 3 (Critical Thinking):**

- "Why would it be impossible to run 10 km using only anaerobic respiration?"
- Pair discussion, then whole-class consensus:
  - Expected answer: "Not enough ATP produced; would run out of glucose; body can't sustain that pace without aerobic system"
  - Teacher deepens: "Right—and lactate/H+ would accumulate so much, muscles would fail"

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*Exit Ticket & Formative Check (5 minutes)*

**HITS Used:** Metacognition + Descriptive Feedback

"Rate your understanding (1–5):

- I can read and interpret data tables: ___
- I can identify lactate threshold in the data: ___
- I can explain why ATP yield matters to Maya: ___"

Teacher reviews to inform Day 3 emphasis on lactate misconception

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## DAY 3: LACTATE & TRAINING ZONES

**Duration:** 1 class period (50-60 minutes)
**Bloom's Levels:** Understand (Level 2) → Analyze (Level 4) → Evaluate (Level 5)

### Activity Flow

*Opening Misconception Hook (5 minutes)*

**HITS Used:** Questioning + Explicit Vocabulary Instruction

**Warm-up question:** "Is lactate bad? Is it a waste product that poisons muscles? Write your initial answer on your whiteboard."

- Students hold up; teacher scans responses
- **Anticipated:** Many will say "yes, lactate is bad" (this is the common myth)
- Teacher: "Interesting! That's what most people—even some coaches—believe. Today we're going to challenge that idea."

**Why this works:** Surfaces misconceptions early; creates cognitive dissonance that motivates learning

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*Direct Instruction: The Real Culprit — H+ Ions, Not Lactate (8 minutes)*

**HITS Used:** Explicit Teaching + Modeling + Scaffolding

**Teacher-led explanation with visual:**

- Draw two columns on whiteboard:

```
LACTATE (the molecule):        H+ IONS (the real villain):
- Useful fuel                  - Lower pH (acidic)
- Can be used by heart/brain   - Interfere with muscle contraction
- Transported in blood         - Cause the "burn"
- NOT toxic!                   - Recovers as pH returns to normal
```

- **Analogy:** "Lactate is like the packaging material from a delivery. H+ ions are like packing peanuts that spill everywhere and get in the way. We blame the package, but really it's the peanuts causing trouble."

- Reference Table 2: Point out "Post-exercise recovery" row—lactate returns to 1.0 in ~1 hour. "If lactate were truly toxic, it wouldn't recover so quickly. But H+ recovers as breathing returns muscles to normal pH."

**Explicit Vocabulary (Tier 2):**

- **Acidosis** = pH drops below normal; H+ accumulates
- **Buffer** = something that counteracts acidity (sodium bicarbonate is a buffer)
- **Lactate threshold** = intensity where lactate production = clearance rate

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*Think-Pair-Share: Correcting the Misconception (7 minutes)*

**HITS Used:** Think-Pair-Share + Metacognition + Questioning

**Think (2 min):** Students individually write: "Why is lactate NOT the enemy of athletic performance?"

- Expected answer: "Because lactate itself is useful; H+ ions cause acidosis, not lactate"

**Pair (2 min):** Explain answer to a neighbor. Refine thinking based on discussion.

**Share (3 min):** Teacher calls on 2–3 pairs. Provides descriptive feedback:

- "I like how you connected lactate recovery to the idea that it's not toxic."
- "Let's push deeper: If lactate isn't toxic, why do muscles still feel the 'burn' during intense exercise?"
  - (Answer: H+ accumulation, not lactate)

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*Small Group Card Sort Activity: Lactate Myth vs. Fact (8 minutes)*

**HITS Used:** Small Group Learning + Collaborative Learning

**Prepare index cards with statements:**

- "Lactate is a waste product" (MYTH)
- "H+ ions cause muscle acidosis" (FACT)
- "Lactate can be used as fuel by the heart" (FACT)
- "Lactate causes the burning sensation" (MYTH — it's H+)
- "Your muscles produce lactate when oxygen is low" (FACT)
- "Lactate poisoning causes fatigue" (MYTH)
- "Lactate can be converted back to glucose in the liver" (FACT)
- "Training increases lactate threshold" (FACT)

**Group task (3–4 per group):**

- Sort cards into MYTH vs. FACT
- Discuss reasoning for each sort
- One student from each group shares one card & reasoning

**Why this works:** Active learning; students physically engage with misconceptions; reinforces correct terminology

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*Part V Introduction: Training Zones (12 minutes)*

**HITS Used:** Explicit Teaching + Scaffolding + Questioning

**Teacher explains with Figure 5 & Table 3:**

- "Now that you know lactate and H+ are different, and you know when they accumulate, we can talk about **smart training**."
- Point to Figure 5: Three training zones based on lactate levels
  - **Zone 1 (Recovery):** 1–2 mmol/L, 60–70% max HR — aerobic base building
  - **Zone 2 (Steady State):** 2–4 mmol/L, 70–80% max HR — lactate threshold work
  - **Zone 3 (Threshold/$VO_2$ Max):** 4–8+ mmol/L, 80–90% max HR — high intensity
- Teacher: "Maya was doing Zone 3 intensity EVERY DAY. No wonder she hit the wall! Her aerobic base was never fully developed, and she wasn't allowing recovery."

**Transition question:** "If you had to design Maya's training week, which zones would you prioritize? Why?"

- Brief pair discussion, then share

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*Part V Questions — Individual + Pair Work (15 minutes)*

**HITS Used:** Questioning + Targeted Instruction + Metacognition

**Question 1 (Understand):** "What is Maya's lactate threshold based on the data from Part III?"

- Answer: 4 mmol/L (from Table 1 & Figure 1)
- Numeracy skill: Identifying a specific value from a graph

**Question 2 (Understand):** "If Maya wants to build her aerobic base, which zone should she focus on?"

- Answer: Zone 1 (Table 3)
- Teacher provides descriptive feedback: "Right. Zone 1 builds endurance. Zone 3 would exhaust her without the base."

**Question 3 (Apply):** "Maya's max heart rate is 200 bpm. Calculate the heart rate range for each zone."

- **Numeracy skills developed:** Percentage calculation
  - Zone 1: 60–70% of 200 = 120–140 bpm
  - Zone 2: 70–80% of 200 = 140–160 bpm
  - Zone 3: 80–90% of 200 = 160–180 bpm
- Teacher models first calculation on board, then students do remaining two

- Use individual whiteboards for peer checking

**Question 3b (Apply):** "If Maya does one workout in each zone this week (plus one rest day), how many total minutes of training?"

- Table 3 durations: Zone 1 (60 min) + Zone 2 (40 min) + Zone 3 (15 min) = 115 min
- **Numeracy skill:** Addition; understanding that training quality matters more than volume

**Question 4 (Evaluate):** "Compare Maya's old training (hard every day) to Kai's new plan. What's better? Why?"

- Pair discussion
- Expected reasoning: "Kai's plan gives aerobic system time to adapt, allows recovery, trains lactate clearance at Zone 2, and avoids burnout"
- Teacher deepens: "Exactly. This is what sports scientists call **periodization**—strategic variation of intensity and volume"

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*Exit Ticket (5 minutes)*

"One myth I used to believe was ___. Now I know ___."

- Collects for feedback on misconception correction success

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## DAY 4: GLYCOGEN & NUTRITION

**Duration:** 0.5–1 class period (25–50 minutes depending on math depth)
**Bloom's Levels:** Understand (Level 2) → Apply (Level 3)

### Activity Flow

*Hook: "Fuel the Machine" (3 minutes)*

**HITS Used:** Questioning

"You've figured out the training plan. But what about fuel? Can Maya race hard if she didn't eat properly?"

- Brief pair discussion: "What should an athlete eat before a race?"
- Teacher: "Good guesses! Today we're connecting biochemistry to actual food choices."

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*Direct Instruction: Glycogen & Fuel (7 minutes)*

**HITS Used:** Explicit Teaching + Scaffolding

**Teacher explains with Figure 6 & Table 4:**

- **Glycogen** = glucose stored in muscles (400–500 g) and liver (100–120 g)
- "During a 10 km race, your muscles burn through this glycogen. If you start with low glycogen, you'll shift to anaerobic sooner and hit the wall."
- Point to Figure 6: "Muscle glycogen depletes faster after 60 minutes. That's why distance athletes **carb-load**—they maximize glycogen stores before a race."

**Explain Table 4 (Carb-Loading Protocol):**

- Days 7–5: Normal intake (deplete glycogen baseline)
- Days 5–3: High intake (rebuild glycogen)
- Days 3–1: High intake + minimal exercise (maximize storage)
- Race day: 2–4 g/kg carbs (fuel without heaviness)

Teacher: "Notice the pattern: deplete, then super-load. Your body responds by storing extra glycogen."

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*Small Group: Data Interpretation (10 minutes)*

**HITS Used:** Small Group Learning + Questioning

**Question 1 (Understand):** "What is glycogen and where is it stored?"

- Pair discussion, whiteboard share

- Teacher confirms: “Muscle and liver”

**Question 2 (Data Interpretation):** “Look at Table 4. On Day 5, how much carbohydrate should Maya consume per kg of body weight?”

- Answer: 8–10 g/kg
- **If Maya weighs 58 kg:**
  - 8 g/kg × 58 = 464 g carbs minimum
  - 10 g/kg × 58 = 580 g carbs maximum
- **Numeracy skill developed:** Multiplication; working with units (g/kg); real-world application
- Teacher models first calculation, then students complete the second

**Question 3 (Apply):** “Maya’s normal breakfast = 80 g carbs. For race day (3 hrs before), she needs 2–4 g/kg carbs. If she weighs 58 kg:”

- Minimum: 2 g/kg × 58 = 116 g
- Maximum: 4 g/kg × 58 = 232 g
- **Does her normal breakfast (80 g) fit?**
  - Answer: No, it’s below the 116 g minimum
  - Interpretation: “She needs to eat MORE on race day to get enough carbs without feeling too heavy”
- **Numeracy skills:** Range calculations; comparing values; real-world problem-solving
- **Inquiry skill developed:** Applying scientific understanding (glycogen depletion) to personal decision-making (nutrition planning)

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*Question 4 (Evaluate) — Whiteboard Debate (8 minutes)*

**HITS Used:** Questioning + Metacognition + Small Group Learning

“Some athletes try to lose weight before a race by eating less. Why is this a TERRIBLE idea?”

- **Anticipated correct answer:** “Low glycogen stores mean hitting the wall earlier; can’t sustain aerobic intensity; body shifts to anaerobic sooner”
- **Teacher deepens:** “Exactly. You’d sabotage your own race. This is why nutrition science matters—it’s not just about calories; it’s about biological timing.”
- Pair debate: One student argues why it’s bad, partner plays “devil’s advocate” (briefly). Then swap.
- Share out reasoning

*Exit Ticket (5 minutes)*

"If I were coaching Maya, I would tell her ___ about nutrition because ___."

- Checks application of nutrition science to real coaching

## DAY 5: RACE DAY & SYNTHESIS

**Duration:** 1 class period (50–60 minutes)
**Bloom's Levels:** Understand (Level 2) → Analyze (Level 4) → Evaluate (Level 5) → Create (Level 6)

### Activity Flow

*Opening: Part VII Read-Aloud (5 minutes)*

**HITS Used:** Literacy Integration

**Teacher reads "The Ultimate Test" aloud** (or students read silently), emphasizing the three race phases and how Maya's understanding made a difference.

**Comprehension question:** "What was different about this race compared to her training run?"

- Expected: "She understood her lactate threshold, trained smartly, carb-loaded, and didn't panic when muscles burned"

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*Final Questions: Structured Write-Pair-Share (25 minutes)*

**HITS Used:** Questioning + Metacognition + Think-Pair-Share

**Question 1 (Understand):** "Describe what was happening metabolically in Maya's body during each phase of the race (0–3 km, 4–8 km, 9–10 km)."

- **Individual write (5 min):** Students write in own words
  - 0–3 km: Aerobic; steady HR; breathing controlled; using stored glycogen efficiently
  - 4–8 km: Lactate threshold; muscle lactate rising; H+ ions accumulate slightly but tolerable; trained to handle this
  - 9–10 km: $VO_2$ max; intense lactate & H+; muscles burning; but aerobic base strong enough to finish
- **Teacher models first phase on board, then students complete**
- **Numeracy insight:** Heart rates tell the story (145 → 165 → 180 bpm)

**Question 2 (Analyze):** "Compare Maya's failed training run (hitting the wall at 4 km) to her successful race (finishing strong at 10 km). What changed in her metabolism?"

- **Pair discussion (5 min):** Identify specific metabolic differences
  - Training run: Aerobic system overwhelmed at 4 km; lactate threshold not adapted
  - Successful race: Aerobic base built up; lactate threshold improved; body could sustain higher intensity longer; glycogen stores full
- **Teacher descriptive feedback:** "You're connecting training adaptations to race performance—that's systems thinking!"

**Question 3 (Evaluate):** "If Maya had NOT carb-loaded, predict what would have happened at the 8–9 km mark using the glycogen depletion graph."

- Reference Figure 6
- Expected: "Glycogen would be more depleted; she'd shift to anaerobic sooner; hit the wall around 8–9 km like in training"
- **Inquiry skill:** Making predictions based on data and biological mechanisms
- **Critical thinking:** Understanding causation (low glycogen → anaerobic shift → wall)

**Question 4 (Evaluate & Create):** "Why was understanding the SCIENCE of metabolism (not just 'running harder') key to Maya's success?"

- **Individual reflection (3 min):** What did scientific knowledge give her?
  - Confidence (she understood what was happening)
  - Strategy (structured training zones instead of random hard runs)
  - Nutrition plan (carb-loading timed correctly)
  - Perspective (lactate ≠ enemy; training brings adaptation)
- **Whole class share:** Teacher creates synthesis on board
  - "Science gave Maya agency—power to control her outcome, not just hope it worked"

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*Creative Application: Design Your Own Training Plan (20 minutes)*

**HITS Used:** Questioning + Scaffolding + Small Group Learning

**Challenge Question (Bloom's Level 6 - Create):** "Design a complete 2-week training program for a soccer player who needs to improve their anaerobic capacity for short, intense sprints."

**Requirements:**

- Identify training zones and durations appropriate for soccer (high-intensity, repeated sprints)
- Include frequency of each zone type per week
- Explain how this develops anaerobic metabolism
- Create a visual representation (table, chart, or diagram)

**Scaffolding provided:**

- Reference Table 3 structure (students may adapt for their athlete)
- Guiding questions:
  - "How often does a soccer player sprint? (This determines intensity focus)"
  - "Should a soccer player spend more time in Zone 1 or Zone 3? Why?"
  - "How would recovery differ from a distance runner's plan?"

**Instructional approach:**

- **Option 1 (Pairs):** Collaborative design using poster board
- **Option 2 (Small groups):** Design as a team; create shared responsibility
  - Role 1: Timekeeper
  - Role 2: Scribe (writes zones, durations)
  - Role 3: Scientist (explains the metabolic reasoning)
  - Role 4: Visualizer (sketches or organizes the visual)

**Teacher circulates, providing:**

- **Descriptive feedback:** "I see you've allocated 20% Zone 3 time. Can you explain why that's enough for soccer without overdoing it?"
- **Scaffolding prompts:** "What does the research from Part V tell us about lactate threshold training? Can you apply that here?"

**Gallery Walk (Optional):** Post plans around room; students note one thing they learned from another team's design

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*Formative Exit Ticket & Self-Assessment (5 minutes)*

**HITS Used:** Metacognition + Spaced Practice

Students complete self-assessment on success criteria:

- I can explain aerobic vs. anaerobic respiration: Emerging / Developing / Proficient / Excelling
- I can interpret physiological data: ___
- I can correct lactate misconceptions: ___
- I can apply training/nutrition science: ___
- I can design customized training: ___

**Teacher action:** Review to identify students needing reinforcement before summative task

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## BLOOM'S TAXONOMY PROGRESSION (ACROSS THE WEEK)

| Day | Level 1 (Remember) | Level 2 (Understand) | Level 3 (Apply) | Level 4 (Analyze) | Level 5 (Evaluate) | Level 6 (Create) |
|---|---|---|---|---|---|---|
| **Day 1** | Vocabulary (ATP, aerobic, anaerobic) | Explain respiration types | Predict lactate increase | — | — | — |
| **Day 2** | — | Read graphs/tables | — | Identify lactate threshold; compare ATP yield | Justify why 10 km can't be anaerobic | — |
| **Day 3** | — | Define lactate vs. H+ | Calculate HR zones | Analyze training zones | Evaluate "no pain, no gain" myth | — |
| **Day 4** | — | Define glycogen | Calculate carb needs | Interpret glycogen depletion | Justify carb-loading protocol | — |
| **Day 5** | — | Describe race metabolism | — | Compare training run vs. race | Predict outcomes with/without carb-loading; judge importance of science | **Design 2-week training program** |

**Progression design:** Students move from simple recall (Day 1) through analysis and evaluation (Days 2–4) to **synthesis and creation** (Day 5). Each day builds on prior understanding.

## NUMERACY SKILLS DEVELOPED

| Skill | Day | Activity | Context |
|---|---|---|---|
| **Reading & interpreting data tables** | Day 2 | Table 1 analysis | Identifying lactate threshold |
| **Comparing ratios & magnitudes** | Day 2 | Figure 2 (ATP yield) | "How many times more ATP?" (32 ÷ 2 = 16x) |
| **Percentage calculations** | Day 3 | Heart rate zone calculations | Zone 1: 60–70% max HR; Zone 3: 80–90% max HR |
| **Multiplication (real-world context)** | Day 4 | Carb loading calculation | 8 g/kg × 58 kg = 464 g carbs |
| **Range calculations** | Day 4 | Recommended carb intake | 2–4 g/kg; finding min/max values |
| **Comparing values** | Day 4 | Does breakfast fit recommendation? | 80 g (actual) vs. 116–232 g (needed) |
| **Addition & totaling** | Day 3 | Weekly training minutes | Zone 1 (60) + Zone 2 (40) + Zone 3 (15) = 115 min |
| **Interpreting line graphs** | Day 2, Day 4 | Lactate levels & glycogen depletion | Identifying trends over distance/time |

**Intentional design:** Numeracy integrated throughout, not as isolated math; always connected to biological meaning.

## INQUIRY SKILLS DEVELOPED

| Inquiry Skill | Day | Activity | Biological Context |
|---|---|---|---|
| **Observing & questioning personal experience** | Day 1 | Think-Pair-Share (hitting the wall) | Personal athletic experience → cell science |
| **Making predictions** | Day 1 | "What happens to lactate during intense 4 km?" | Predicting cellular response to exercise |
| **Interpreting data** | Day 2 | Graph & table analysis | Identifying lactate threshold; trends |
| **Analyzing relationships** | Day 2 | Connecting $O_2$ consumption to HR | Asking "Why did HR jump when $O_2$ increased?" |
| **Identifying causes** | Day 3 | Distinguishing lactate vs. H+ | Root cause analysis: what actually causes muscle burn? |
| **Evaluating claims** | Day 3 | Lactate myth vs. fact card sort | Critically examining common beliefs against evidence |
| **Applying knowledge to new situations** | Day 4, Day 5 | Calculating carb needs; designing soccer training | Transfer of learning to different athletes/sports |
| **Making predictions with evidence** | Day 5 | "Predict outcome without carb-loading" | Using glycogen graph to predict performance |
| **Systems thinking** | Day 5 | Compare training run vs. race | Seeing how training → metabolic adaptation → race success |

**Assessment method:** Observe which students ask "why" questions (deeper inquiry); who make predictions with reasoning (not just guesses); who apply knowledge flexibly.

## HIGH IMPACT TEACHING STRATEGIES (HITS) INTEGRATION

| HITS | Days Used | Specific Application | Why This Works |
|---|---|---|---|
| **Learning Goals & Success Criteria** | All days | Posted daily; referred to during lessons; students self-assess on exit tickets | Teacher clarity = student ownership |
| **Explicit Vocabulary Instruction** | Days 1, 3 | ATP, aerobic, anaerobic, lactate, H+, glycogen, acidosis, lactate threshold | Content-specific vocabulary; multiple exposures |
| **Descriptive Feedback** | All days | "I see you identified lactate threshold… Now can you explain what it means biologically?" | Corrects misconceptions; provides next steps |
| **Questioning** | All days | Think-Pair-Share; open questions; probing questions; reflection questions | Engages higher-order thinking; checks understanding |
| **Direct/Explicit Teaching** | Days 1, 2, 3, 4 | Modeled graph reading; lactate explanation; HR zone calculation; carb-loading protocol | Clear instruction before independent work |
| **Scaffolding** | All days | Gradual release: I do (model) → We do (guided) → You do (independent) | Accessibility for all learners |
| **Spaced Practice** | All days | Repeated encounters with lactate concept (myth on Day 1; explanation Day 3; application Day 5) | Improves retention; deepens understanding |
| **Metacognition** | All days | Exit tickets; self-assessments; "What does this tell us?"; "Why does this matter?" | Students think about their thinking |
| **Small Group Learning** | Days 2, 3, 4, 5 | Flexible groups by readiness; card sort; collaborative design | Peer learning; focused conversations |
| **Targeted Instruction** | All days | Different Q versions for different groups; differentiated readings | Meets varied student needs |

### Why This Combination Works

- **High teacher-student interaction** (Explicit Teaching + Questioning) keeps students engaged
- **Spaced practice & metacognition** help students remember content AND reflect on their learning

- **Small group + scaffolding** ensure all students access material at their level
- **Feedback loops** (Descriptive Feedback + Exit Tickets) inform instruction daily

## ASSESSMENT STRATEGY

### Formative (Throughout the Week)

- **Exit tickets** after each day (identify misconceptions early)
- **Whiteboards** during lessons (real-time understanding checks)
- **Observation** during small group work (HITS: Questioning)
- **Self-assessment rubrics** (HITS: Metacognition)

### Summative (End of Week)

- **Quiz on Part III data interpretation** (Can they read & analyze? Bloom's Level 3–4)
- **Quiz on lactate misconceptions** (Part IV; Bloom's Level 2)
- **Training program design** (Bloom's Level 6: Create)
- **Reflection paper:** "Explain why Maya succeeded this time" (Synthesis; Bloom's Level 5)

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## DIFFERENTIATION STRATEGIES

| Student Group | Tier 1 (Aerobic Base) | Tier 2 (Maintain & Extend) | Tier 3 (Challenge & Create) |
|---|---|---|---|
| **Who** | Below-level; need scaffolding | Grade-level; progressing steadily | Advanced; ready for application |
| **Day 1 Reading** | Partner read-aloud | Independent reading | Annotate concepts; discuss with peer |
| **Day 2 Graphs** | Simplified Figure (fewer data points); guided analysis | Standard figures; guided questions | Analyze all three figures independently; make predictions |
| **Day 3 Calculations** | Model first; fill-in-the-blank worksheet | Complete calculations; explain reasoning | Derive formulas; justify zone percentages |
| **Day 4 Carb Calcs** | Pre-filled table; calculate one example | Calculate range (min/max) | Design individualized protocol for different athletes |
| **Day 5 Design** | Adapt provided template (zones already listed) | Design from scratch with guiding questions | Design with rationale based on sports science; present to group |

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## SPECIAL NOTES FOR GRADE 12 (SBI4U) vs. GRADE 11 (SBI3U)

**Grade 12 students may:**

- Go deeper into enzyme kinetics (activation energy; lactate dehydrogenase)
- Explore cellular respiration at the molecular level (ETC details)
- Research $VO_2$ max testing protocols
- Analyze research articles on lactate metabolism

**Grade 11 students may:**

- Stay at the systems level (organs responding to exercise)
- Focus on practical application (training design; nutrition)
- Explore misconceptions deeply (lactate myth)

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## MATERIAL REQUIREMENTS

- **Figures 1–7** (insert provided images from case study)
- **Individual whiteboards & markers** (formative checks)
- **Chart paper & markers** (small group sharing)
- **Index cards** (Lactate Myth vs. Fact card sort)
- **Calculators** (percentage & multiplication calculations)
- **Optional:** Heart rate monitors (kinesthetic extension; students measure own lactate threshold)

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## LITERACY & LANGUAGE SUPPORT

**Vocabulary Support:**

- Post vocabulary chart in classroom; add words as they emerge
- Use student-friendly definitions (e.g., "ATP = energy money for cells")
- Encourage students to use vocabulary in sentences

**For English Language Learners (ELL):**

- Pair with strong language models for small group work
- Provide sentence frames: "Lactate is ___. H+ ions are ___."
- Use visuals (diagrams, graphs) alongside text
- Pre-teach vocabulary; review frequently

**For students with reading differences:**

- Use read-aloud (teacher or peer)
- Provide graphic organizers (compare/contrast table for aerobic vs. anaerobic)
- Break questions into smaller components