Developing and Refining Text-Based Investigations on Homeostasis in High School Classrooms: Lessons from Collaborative Design-Based Research

Project READI Technical Report #23

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Project READI operated as a multi-institution collaboration among the Learning Sciences Research Institute, University of Illinois at Chicago; Northern Illinois University; Northwestern University; WestEd's Strategic Literacy Initiative; and Inquirium, LLC. Project READI developed and researched interventions in collaboration with classroom teachers that were designed to improve reading comprehension through argumentation from multiple sources in literature, history, and the sciences appropriate for adolescent learners. Curriculum materials in the READI modules were developed based on enacted instruction and are intended as case examples of the READI approach to deep and meaningful disciplinary literacy and learning.

Introduction

The READI intervention is comprised of Professional Development and curricular modules that support teachers' uptake of instructional practices that support evidence-based argument with text-based investigations. The curricular modules described herein is one of the set of resources that were provided to the implementing teachers as part of an instructional progression over the course of the semester that deepens both teachers support of and students' engagement with disciplinary texts for the purposes of developing explanatory accounts for real-world phenomena. [See Project READI Technical Report #17 on Designing text-based investigations in science].

Methods

Topic selection. We collaborated with two high school biology teachers to select human homeostasis as a topic for the module, based on the college readiness frameworks (Annenberg Institute for School Reform et al., 2014), the Common Core State Standards (Council of Chief State School Officers, 2010), the Chicago Public School Biology content frameworks and the Next Generation Science Standards (NGSS Lead States, 2013). These documents reflect the national movement for science learning to target big, overarching concepts of the discipline and student's understanding of these concepts to be built through engagement in practices such as argumentation and explanation. They are also key documents that teachers utilize for lesson planning. Our first two meetings with the teacher design partners, we brainstormed the breadth and depth of scientific principles that we wish to target. These brainstorming discussions surfaced key tensions in the design process, and in particular, how deeply to dive into a particular diseases (e.g. sugar and salt balance in the body) versus taking a more generalizable overview (e.g. understanding the signals the body detects and how it responds) that keeps the science principles at the forefront. In the subsequent meetings, we brought text candidates and discussed potential sequencing possibilities, based on the causal models that were created for each phenomenon and identified affordances for building a repertoire of close reading practices. The teachers then used these texts with their students. The final set of meetings, we debriefed with teachers and probed for how these texts were used in the classroom, its affordances for close reading and knowledge building, and the kinds of texts and tasks that would support these sensemaking discussions.

Through the design process, we decided to focus on 2 particular cases that exemplify how feedback within and between organ systems maintains homeostasis in the human body. The first half of the module focuses on sodium balance in the human body – both cases of when the balance is in check and when it is disrupted (hypo and hypernatremia). In line with our design principles, this module includes multiple texts of multiple modalities (clinical studies of hypernatremic patients, news stories, diagrams from Biology textbooks, and texts from the New York Times and The New Yorker). The second half of the module focuses on how the body maintains appropriate blood sugar levels and cases when this balance is disrupted (e.g. Diabetes). The Homeostasis module text set, taken as a whole, includes both texts that are specific to mechanisms that govern salt and sugar balance, as well as more generalized texts that describe on the principles of human homeostasis.

Drafting causal models. After selecting these two phenomena as the central focus of the Homeostasis module, research members of the design team studied the phenomena in detail (consulting with multiple reputable online and textbook sources) to generate causal model that would accurately describe and explain the feedback mechanisms that regulate salt and sugar balance in the human body (see Figures 1-3). These explanatory models were then brought to the teacher partners and discussed and revised for accuracy and simplicity. Through this discussion, we also identified the critical features of these explanatory models that would be set as targets for students learning, as well as the features developmentally or instructionally inappropriate for 9th grade high school Biology students. These complex, evidence-based models served as the guideline for text-selection process, helping us determine the affordances of a given text for scientific knowledge building. We simultaneously evaluated whether or not texts afforded opportunities to engage students in discussions of the close reading practices and variety of texts representative of those encountered in science.

Classroom enactment, reflection and revision. Texts were identified, formatted, and then discussed by the entire design team. Insights and revisions to the preliminary text set were informed by our conversations with the two design teachers as they enacted the text set in their classrooms and then reflected on this experience with us, in line with the design-based research tradition (e.g. Barab, 2006; Cobb et al., 2003). Members of the science team observed a single lesson in the 9th grade teachers' classroom in which these texts were used as instructional materials. Two-2 hour meetings with these teachers were used to reflect on the affordances of each text within this module for supporting close reading practices and supporting knowledge building of the principle of homeostasis. The design team members took notes on the teachers reflections and used these to re-sequence texts and add additional texts after gaps were identified. The teachers also noted the specific tasks and activities that supported meaning making. These suggestions were compiled into a data table and informed the design of the final text set for the homeostasis module.

A theme in our conversations with the teacher design partners was around the issue of the scope and sequence of the text set opportunities to support the evidence-based argument we intend for students to engage in and around these texts. For instance, one of the Biology teachers raised that hypo and hypernatremia texts talk about salt concentration, but without explicit descriptions of whether this referred to extra- or intra-cellular concentrations, citing this both as something in need of clarification as well as an opportunity to build on what students already know about hypo and hypertonic solutions from previous grade levels. In response, we added a text on the components of human blood, describing that solutes, such as sodium, reside in the plasma component of blood and play important functions in the human body. This example reflects how the process of selecting texts, sequencing them, and talking with teacher partners surfaced the kinds of prior knowledge that students have, can draw on, or gaps in kind of causal reasoning that we wish for students to engage in through the texts.

Situating module within instructional progression. After this design, implementation and reflection phase, we generated a preliminary draft of the module, including teacher materials, student interactive notebook, Reader (compilation of texts). In preparation for the use of these modules with the implementing teachers, our design team reviewed these materials in tandem with the instructional progressions for the semester sequence and determine the when specific close reading practices will be introduced and how they will deepen over time as a result of engagement with the material supports for meaning making. Members of the Chicago and California teams met at to do this work. This informed our understanding how to support students in deepening close reading and knowledge building practices from one module to the next [See Project READI Tech Report #17 for an articulation of these instructional progressions].

Further development for the efficacy study. Finally, we created and administered a survey with the implementing teachers, asking about their typical semester topic sequencing. Homeostasis was designed to be the first READI module. The full READI module included the interactive notebooks and readers for students, as well as accompanying evidence/interpretation (E/I) charts to support students in identifying text-based evidence that addresses the inquiry question "How does your body work to maintain balance? What happens when this balance is disrupted?" The Homeostasis module deepens students' engagement with multiple texts, builds on their familiarity with scientific models (first introduced in the Reading Models Module, as described in Technical Report #22) by scaffolding the practice of developing explanatory models using multiple sources for scientific phenomena. The final version of the Homeostasis Student Investigation and Homeostasis Reader can be found in Project READI Curriculum Module Technical Report CM #28.

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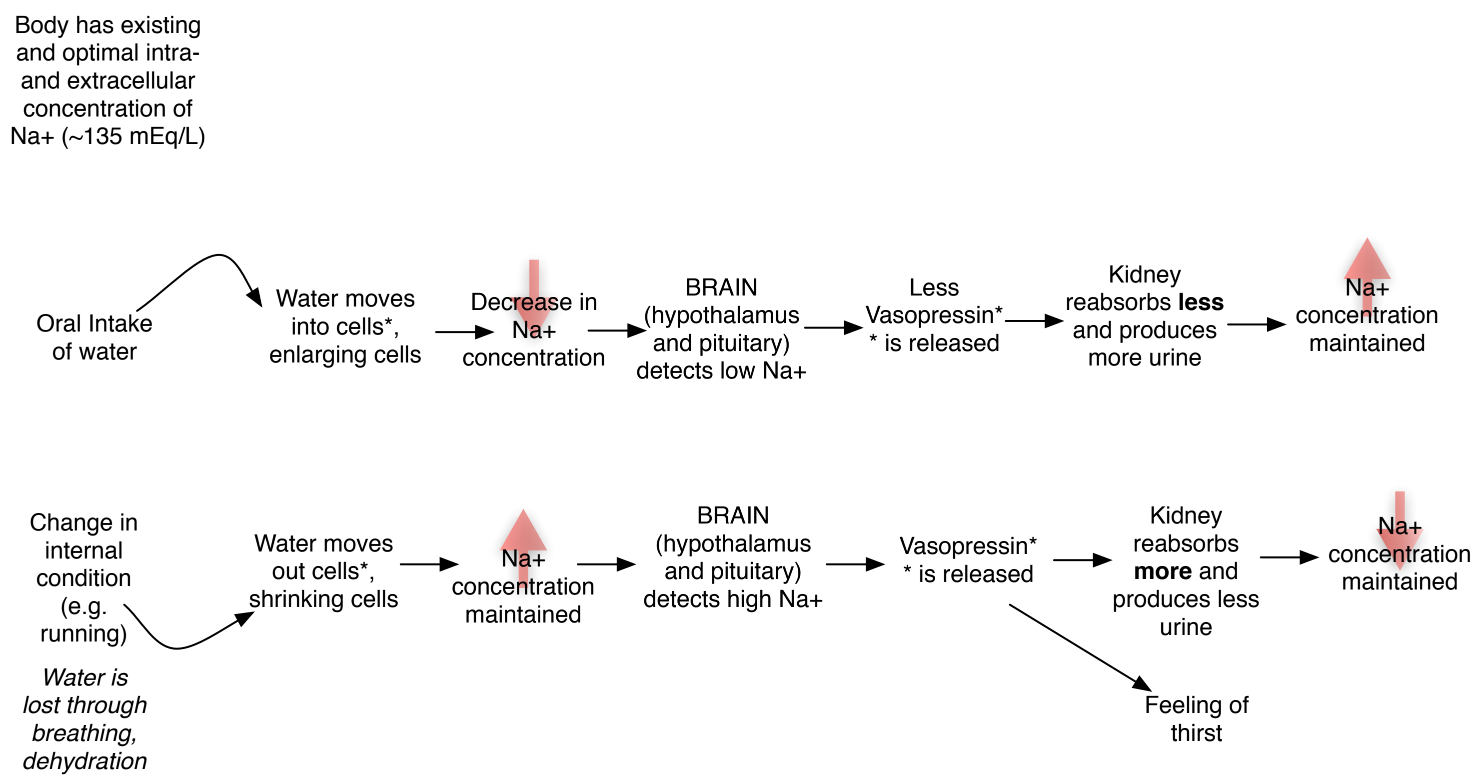
Figure 1. Blood sodium regulation under normal conditions



* movement of water is passive, and responsive to differences in relative concentrations in/outside of cells. Thus sodium induces the movement of water across the cell membrane. Movement of Na+ is active, requiring use of ATP. ** Vasopressin = ADH.

Figure 2. Sodium imbalance (hypo and hypernatremia)

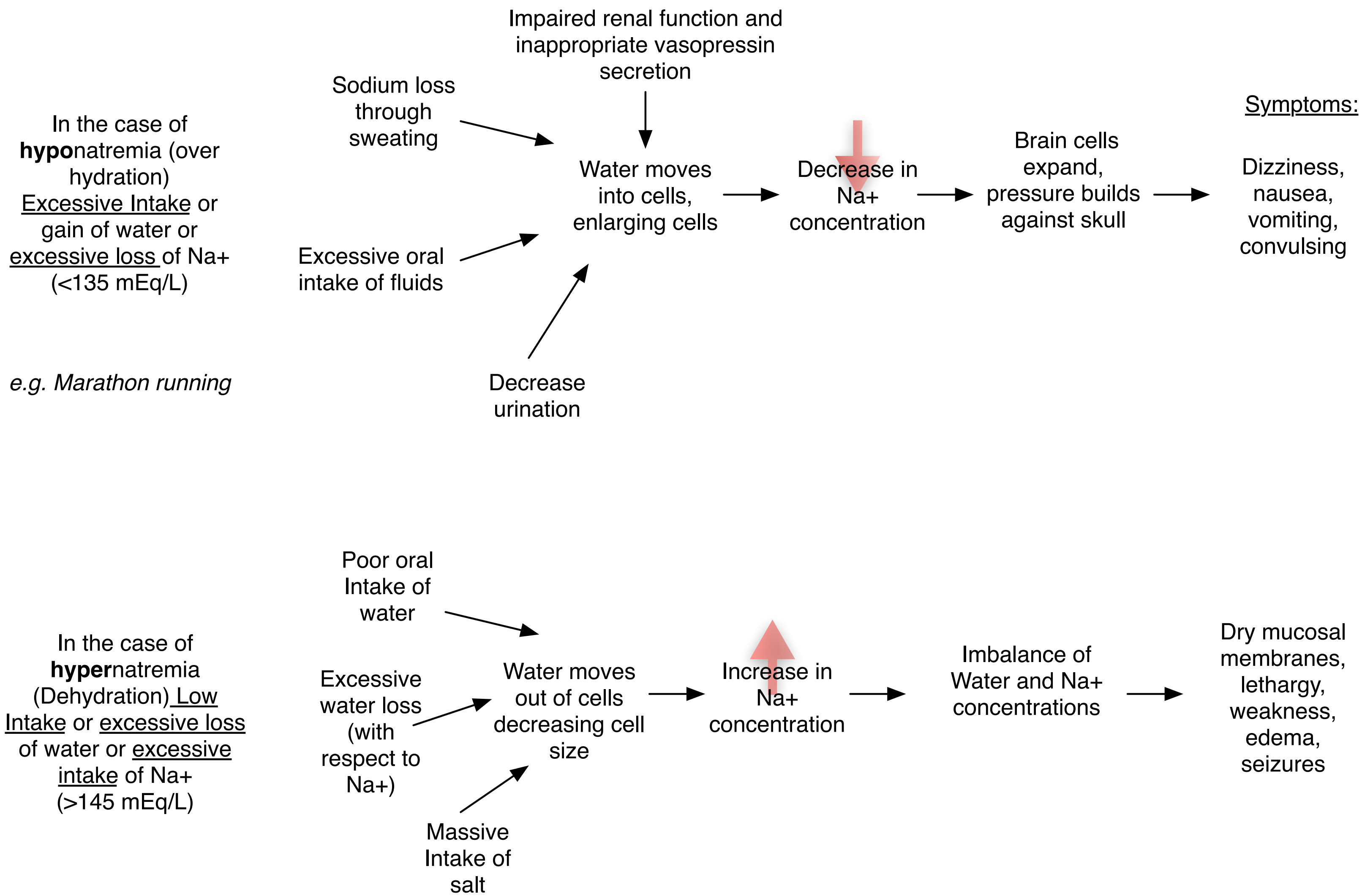
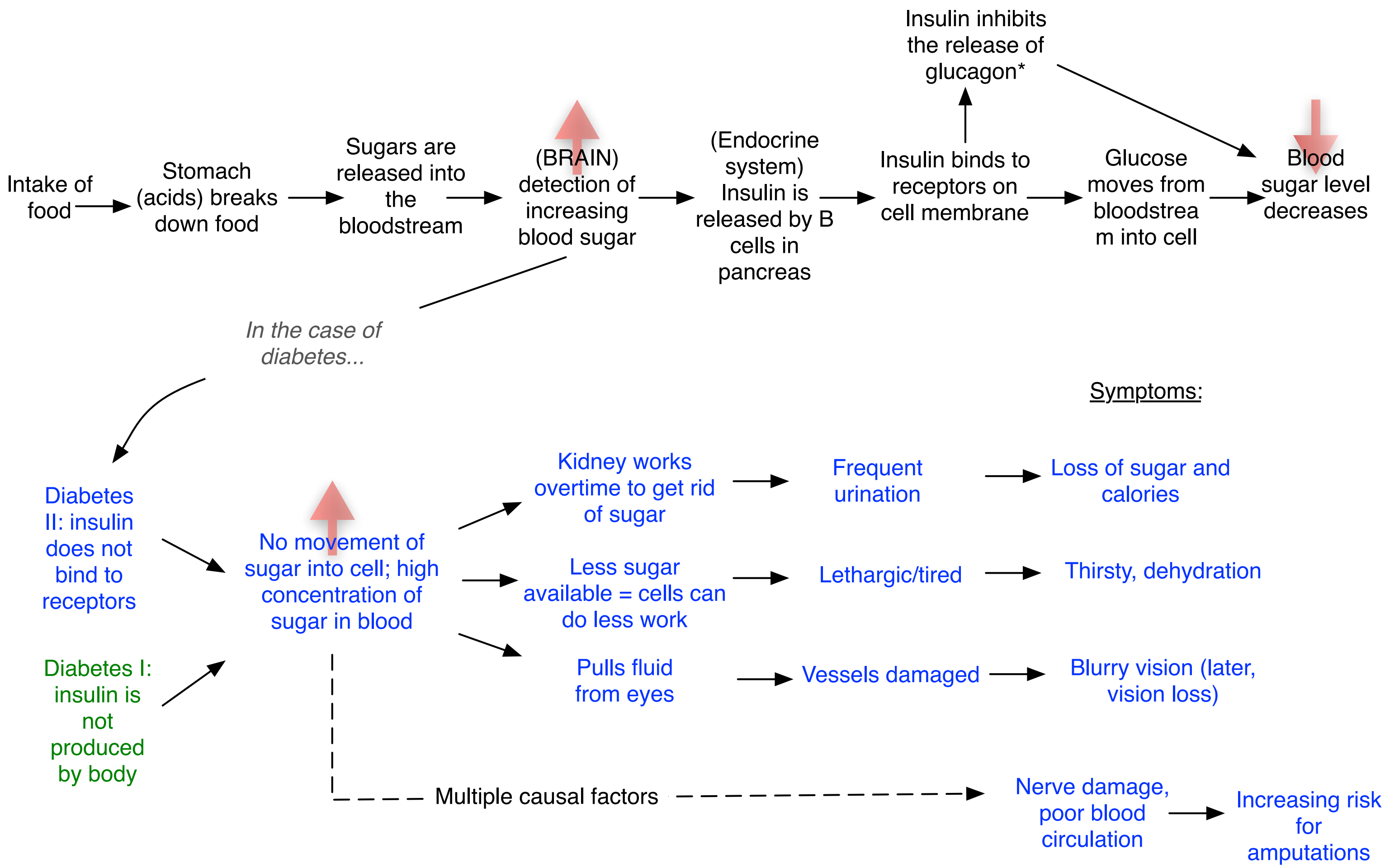


Figure 3. Blood sugar regulation & imbalance



* Glucagon (made in in the pancreas) normally converts glycogen to glucose, thus increasing blood sugar levels