

From Physics to Pneumonia: Basic Science for Medical Students

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BACKGROUND

To be a competent physician it is not enough to memorize guidelines, one must have a deep knowledge of the workings of the human body. To do this requires some understanding of the basic sciences (physics, chemistry, biochemistry). How should this knowledge be integrated into medicine?

METHODS

Identified literature related to the benefits of integration, outlined concepts useful to understanding how to integrate basic science, laid out frameworks and principles on which a teacher could base this integration, and constructed examples of curricula following these principles.

RESULTS

Benefits of basic science integration:

1. Improved ability to retain information
2. Enhanced cognitive flexibility
3. Increased engagement
4. Paradigm of curiosity and empowerment

Considerations to integrate effectively:

1. Different needs in different learning phases
2. Coordinate teaching between professors
3. Implement integration at the micro-level
4. Evaluate knowledge in holistic way
5. Encourage metacognition
6. Focus on interest, not only direct relevance

DISCUSSION

What kinds of non-medical information are necessary to learn medicine? What is most helpful in helping medical students learn effectively and efficiently?

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Your ability to turn a glazed doughnut into complex thought is based on the same principle as water flowing down a hill: the universe’s tendency toward lower energy states

SAMPLE EXCERPTS FROM CURRICULAR DEVELOPMENT

“Acidity is a measure of the concentration of hydrogen ions in an aqueous solution. Some molecules consist of relatively electronegative atoms bound to hydrogen ions. It is not that much of a hit, from an energetic perspective, for these atoms to exist separately: the electronegative atom will exist as a negatively charged solo molecule, while the hydrogen will exist as a positively charged solo molecule. This dissociation is possible because the presence of water allows for significant stabilization of the electromagnetic charges. The more energetically stable the separated atoms are, the more acidic the solution will be. There will always be some free hydrogen atoms (H^+) in any aqueous solution, but the number can vary by many orders of magnitude.”

“The second row of the periodic table contains the other most important atoms for biology -- carbon, nitrogen, and oxygen. Remember, the first electron shell on these elements is full (with two), and the second shell has the potential to contain 8 electrons. Thus carbon, with 6 protons (and 6 electrons) has 4 electrons in its outermost shell, with room for 4 more. This means carbon can make 4 bonds with other atoms, nitrogen can make 3, and oxygen 2. The ability of carbon to make 4 bonds is responsible for the incredible versatility and complexity of carbon based molecules.”

“But how does hemoglobin work? The trick with hemoglobin is to allow it to bind when it wants to pick up oxygen but release oxygen when it reaches the target tissues. Human hemoglobin has four subunits, each of which has an iron molecule and each of which can carry a molecule of oxygen. It carries the oxygen because the heme unit is structured in a way to allow for easy binding of the iron to the oxygen in a reversible way. The iron has an extra electron that is somewhat stabilized by the surrounding nitrogenous groups, but not so stabilized that it is not energetically efficient for oxygen to attach itself. That is, the reason hemoglobin is able to bind and release oxygen is because the electron density of the iron is just right such that it is energetically favorable to bind the oxygen, but not so energetically favorable that it cannot be let go.”



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