The body of research on biochemistry education is startlingly small. One reason for less educational research on improving teaching and learning in biochemistry (or other upper-level science) courses than for high enrollment general chemistry undergraduate courses is the research would impact fewer students, due to student attrition in the introductory courses. A second reason could be the inherent complexity and detail of the scientific content. A third reason might be that funding for upper division courses is much less than for lower division introductory courses, thereby making the research more difficult to undertake. However, room for improvement always exists, and just as science is an evolving process so is education. We must be both flexible and open in order to best suit the needs of our undergraduate students and the institutions in which they progress toward their post-collegiate careers in industry, government, graduate/professional school or others.

Scholarly journals such as the Journal of Chemical Education and Biochemistry and Molecular Biology Education regularly publish research papers dedicated to the study and improvement of freshman and lower-level collegiate science courses. Here we examine the research on using traditional and novel methods for the education of upper-level undergraduate students in biochemistry courses throughout the US, including both lecture and laboratory components. We examine the goals, methods—of both lecture and laboratory format classes—and influence of technology on undergraduate biochemistry education in the US, in light of the construction of knowledge, career preparation, and overall utility. We focus on biochemistry education as a field in a state of becoming. Biochemistry education exists between traditional methods of teaching, whereby faculty deliver information to the students, and the more modern methods in which the teacher acts as an experienced facilitator in helping students discover and construct their own knowledge. The evolution of biochemistry education presents a unique opportunity for us to observe and detail the process of improvement.

USING SOCIOCULTURAL THEORY

The goals of typical undergraduate students in biochemistry are nearly as numerous as the students themselves. Many, however, echo this student comment: “My goals for this class are to not just do well but retain the information I learn so that I can carry it over in my career. Also this semester I hope to get accepted into the biomedical program here and earn my PhD in something related to viral research.” Thinking from the perspective of cultural historical activity theory (Engeström, 1987) helps the teacher connect his/her students to their goals (or “objects”) and...
desired "outcomes" (Figure 11.1). Cultural historical activity theory (CHAT) emphasizes the dynamics of learning through social interactions within a community of participants (in our case, biochemistry students). This theory allows the teacher to see the components that can contribute or inhibit a student from progressing toward his or her goals (or "objects"), such as in a biochemistry classroom or laboratory, en route to the student's desired outcomes. Components in higher education teaching of biochemistry might include "tools" (such as technology or the textbook or a personal response system), "schemas" (historical aspects of the culture of learning within the institution), "communities" (such as working together in projects within collaborative groups), and "division of labor" (with reciprocal responsibilities of teacher and students or students with each other in collaborative groups). Therefore, one of the critical aims of biochemistry education should be the preparation of students for graduate or professional school. However, some students proceed to industrial or government jobs, such as employment with pharmaceutical companies or governmental research agencies, and their needs also warrant our attention for inclusion in the teaching approaches taken.

PREPARATION OF THE GRADUATE OR PROFESSIONAL STUDENT

The needs of the graduate or professional student are unique in that for the duration of their graduate work, the student exists at the boundary between being a student and a professional. In general, a graduate student should be learning to perform the functions of a researcher while still constructing new knowledge in the manner of a student. The critical functions of the researcher persona of a graduate or professional student include, but are not limited to literature search and review, original experiment design, data analysis, publication writing, grant writing, and research presentation. As such, the preparation of an undergraduate biochemistry major, for instance, for graduate or professional school should include at the bare minimum an introduction to and activities in each of the above areas—which is not required at many North American institutions. Even at a major southeastern US university, some seniors may graduate without having searched the primary literature, performed original research, or presented research to their peers. Thus, a professional student, such as one enrolling in medical school after graduation from undergraduate school, needs to connect information from one domain of knowledge or experience to another domain and to think critically from evidence provided on patients with certain histories and symptoms. Biochemistry classes that encourage critical thinking across domains help students be prepared for starting medical school.

PREPARATION FOR INDUSTRIAL OR GOVERNMENTAL EMPLOYMENT

Whereas the industrialized, mass-produced educational methods that were once popular decades ago are in decline, we borrow one basic model from that industrial-minded period. As educators we consider ourselves to be suppliers of a critical resource—trained scientists, technicians, and engineers, to a market very much in their demand—America's industrial and governmental institutions. With the pharmaceutical, materials, and a myriad of other industries and governmental institutions demanding trained chemists and biochemists, the education that undergraduate students receive must be thorough and grounded in theory and analytical techniques, as well as being relevant to modern industrial and governmental needs. To that end, the American Society for Biochemistry and Molecular Biology (ASMB, 2007) recommends a curriculum for a program in undergraduate biochemistry and molecular biology. In particular, they highlight a "focus on the concepts, content and topics of the program, as well as the student outcomes that should be expected from the program" (p. 1). This curriculum recommends, in particular, three semesters of biochemistry with several semester laboratories in methods of isolation and instrumental analysis. In addition, ASMB asserts, "research experience is an essential part of the undergraduate experience in biochemistry and molecular biology" (p. 1). In contrast to these statements, one major southeastern US university's biochemistry degree requires only two semesters of biochemistry lecture and one of laboratory, with research experience being an optional but highly encouraged experience, especially with honors students.

With respect to industrial expectations for technician-level workers in the US bioscience industry, three main issues face bioscience baccalaureate workers include a lack of (a) preparedness, (b) an understanding of the learning that industrial employers require, and (c) satisfaction on the part of the worker (Dahms & Leff, 2002). All of these issues could be solved at the level of undergraduate education. We detail later exactly the influence of modern methods of teaching in solving these problems by eschewing the traditional dualistic teaching methods in favor of social constructivist education, with aspects that enhance the students moving to their objects (or goals) and on to their outcomes (as in CHAT). One study focuses on "biologically relevant" chemistry throughout the four-year curriculum, emphasizing early exposure to biochemistry and biochemical ideas even before the introduction of the standard two-semester organic chemistry course (Kirk, Silverstein,
Their unique bioorganic chemistry course promotes the retention and interest of students in two ways—by putting off the fine details of organic chemistry until the third year, when students can decide if they would like to pursue organic chemistry as a field, and by introducing cutting-edge research ideas earlier in the curriculum so that the enthusiasm of the professor teaching the course can help encourage students.

Several criteria for the “ideal education in biochemistry” are salient, including, but not limited to (a) awareness of the major issues at the front of the discipline and (b) ability to assess primary papers critically, dissect a problem, design experiments and understand their limitations, interpret data, collaborate, and think in terms of the “big picture” (Bell, 2001). These concepts are at the core of an ideal education, but are often overlooked in the pursuit of an understanding of the fundamentals, especially when those fundamentals are laid out in a textbook as facts to be memorized instead of knowledge to be sought, understood, and integrated. Modern educational methods seek to bridge this gap and instill a lasting and comprehensive knowledge and a drive for pursuit of knowledge in the discipline of biochemistry.

The demand for well-trained and educated scientists and engineers cannot be understated and, as is well documented, is deemed “critical” by several prominent US institutions, with the S&E workforce growing at 6% annual average rate between 1950 and 2000, much higher than the average 2% rate of growth in employment over the same time period (Science and Engineering Indicators, 2008). However, traditional teaching methods seem to have led to a stagnant, if not declining, level of interest and output of well-prepared students, despite record enrollment numbers at many institutions. The critical idea, common to all of the recommendations and suggestions is to consider the students to be less recipients of an education but rather as participants in their own construction of knowledge, and scientists in their own right, albeit one with little but growing experience.

TRADITIONAL TEACHING METHODS

Behaviorism dominated the literature for the first half of the 20th century. Eventually, ideas started to change, with Piagetian ideas of intellectual development being a powerful force in educational research. During subsequent decades, social constructivism became a major force through the influence of Vygotsky and the Soviet school of activity theory. However, the dominating behaviorist ideas on education influenced the research questions that educational researchers in all fields, including biochemistry, asked about their undergraduate science classes. In the 1990s a movement of educational researchers started to pay attention to the learner using a social constructivist lens, in which the teacher provides an environment to engage the learner and to help connect ideas the learner already knows with the new material to be learned and integrated with prior knowledge.

In a typical four-year university located in the southeastern region of the US, a biochemistry degree curriculum differs from the chemistry curriculum by the addition of two semesters of biochemistry lecture, one semester of biochemistry labor-
tive preparation in the field, by presenting what is essentially an under-trained bio-
chemist in a demanding field. Traditional teaching includes as tools (Figure 12.1) the
textbook, an answer key to the problems at the end of each chapter, and perhaps PowerPoint lecture notes. Characteristic of dualistic learning is little commun-
ity involvement among peers or with the teacher in the learning, except office hours. The schemas of the institution encourage large lectures for increased num-
ber of students with less need to pay for expensive faculty. The division of labor is that the teacher prepares the lecture and the students memorize the knowledge pro-
fessed by the teacher.

MODERN TEACHING METHODS

In comparison to the more traditional teaching methods, we characterize newer teaching methods in the biochemistry classroom and in the laboratory, focused more on the learner. These methods share a common set of ideas—that students can participate and contribute to their learning of new material, that knowledge earned instead of given has greater meaning and retention, and that teaching should more closely approximate application than in prior years. Using the CHAT model, the teacher addresses the tools, schemas, communities, and division of labor pro-
vided to the subjects (students in this case), so that these factors or elements work together to help the subjects move to their objects and outcomes (Figure 12.1).

In the Classroom

New teaching methods help students construct their own knowledge, rather than simply memorize and assimilate a body of facts. This practice, known as social constructivist education, asserts that knowledge is necessarily modeled from experience, and that as experience changes with interaction with others, so does the model (Tobin, 1993). Social constructivism takes into account the communities and the division of labor aspects of CHAT, but not the schemas (which often hold students from achieving their objects) and the tools provided. E-mail communica-
tion with honors chemistry students in freshman chemistry constitutes one impor-
tant tool that allows students to learn in advanced chemistry seminars, including biochemistry (Gilmer, 2002). At the time of her study, Gilmer did not know the value of collaboration (or the other aspects of CHAT), but the study does open her up to understanding the goals of her students as they attempt to learn and under-
stand the concepts in freshman chemistry within a smaller than usual chemistry classroom. For example, Gilmer describes how one student attends an organic division seminar and is surprised to hear argumentation between the speaker and a faculty member. Knowledge of what it is like to be a chemist was revealed through participation and in similar ways the students from Gilmer’s class could learn about the culture of chemistry through their participation in chemistry. Gilmer en-
couraged this in the way she assessed the course, the students could get bonus points if they e-mailed Gilmer a paragraph on their learning at such seminars. Stu-
dents also added paragraphs on the learning environment in their classroom. Thus, the students gave me feedback on how to improve their learning in class. Getting feedback from students both during and at the end of the semester helped me address their needs and helped me reflect on whether or not to continue providing opportunities for students to learn science content and the culture of science from attending seminars. (p. 454)

This type of feedback during the semester can make a huge difference in understanding the students’ issues with the learning environment, as the teacher is in a position to change the teaching, either on the fly or with reflection. Problem-based learning (PBL) may help biochemistry majors become immersed in the literature while encouraging students to “realize their ability to think and learn for them-
selves” (White, 2002, p. 231). White abandons the traditional lecture-based format and sets unusual but realistic expectations for his students as scientists: “I ex-
pect them to identify what they don’t know and need to learn before they go to the library. I expect them to take the initiative and to pursue answers to specific ques-
tions they pose. I don’t expect to be the source of all things students learn in my class” (p. 233). This style of PBL closely mimics the scientific process undertaken by professionals and researchers actively participating in the field. PBL “claims to mimic the way we learn naturally when we confront problems. In principle, PBL reverses traditional education by putting the problem first and using it to motivate learning” (White, 2002b, p. 419). By exposing the students to such an environment early in their careers, White eases the shock of transfer from undergraduate to graduate or professional schools or industry or government. White continues to use PBL in his teaching of biochemistry, as “the nominal course content provides a pro-
tect for a different and more fundamental learning experience” (White, 2007, p. 212). Students in White’s classroom must communicate with each other, as they have a problem to work out together, using the biochemistry literature, and then to communicate their growing constructions with the rest of the students.

Focusing on the communities and the tool of the Internet may be an important way of organizing undergraduate general biochemistry classes (Gilmer, 2004). Her classroom has only one day per week with “lecture,” which really is an outline of the upcoming chapter. On the second day per week, the students work together in their collaborative group, choosing a topic for their next Web-based project, to be uploaded to the Internet. On the third day of each week the students within three collaborative groups present their learning in the form of a website that they cre-
ted to the other students and Gilmer in the classroom. The students in the other seven collaborative groups listen and peer review the presenting groups. Each stu-
dent in the presenting group self evaluates its presentation. Over the semester, each group presents three websites (out of ten created). Another biochemistry professor teaches a parallel group of students using the three-days per week lecture format. The students in both sections that advanced to the second course in this sequence achieved comparably, within experimental error. Gilmer reports that the qualitative data from e-mails from students, forms for peer review, progress forms for groups (on their Web sites), and a final learning environment questionnaire provide valu-
able data for learning about her teaching. CHAT, in conjunction with qualitative
data, allow for the close examination of social interactions and the students' uses of technology in the classroom and in collaborative groups.

Use of small groups of students may help in the cogeneration of ideas for improving the learning environment during the semester in which Gilmer teaches biochemistry. The method of using cognitively dialogue groups developed from educational research in high school classrooms in urban schools. Gilmer meets weekly with four or five students in a group, over lunch, immediately after the class meets, to discuss ideas for improving the learning environment in the classroom (Gilmer & Cirillo, 2007). Students see that she is earnest in wanting to improve the classroom-learning environment. Changes from this input are then formatted and integrated, thus eliminating the typical lag between evaluation and improvement inherent in the typical end-of-semester evaluation system.

Some biochemists use molecular models as a method for allowing students to explore the spatial relationships of compounds, especially with proteins and DNA. Students exposed to physical models demonstrate statistically detectable improvements on tests than by those who are not (Bain, Yi, Beikmohamadi, Herman, & Patrick, 2006). Similarly, doing individual research projects significantly increases students' ability to grasp the biochemical concepts involving intramolecular interactions, especially the concepts of active sites, protein conformational change, and secondary structure when molecular models are used in the teaching (Bateman, Booth, Sirochman, Richardson, & Richardson, 2002). In addition to the use of computer technology for molecular models, teachers may use simulations of instrumental and analytical techniques, often those used in the laboratory. One program simulates gel permeation chromatography of biological macromolecules. This program contains a simple simulation of two large molecules being separated individually, then together, following up with a microscale depiction of the chemistry of separation. Therefore, students could relate to various levels of representation and gain a holistic view of the process of separation (Marson & Torres, 2006). These types of hands-on, constructivist, problem-based instructional methods contribute not only to the development of biochemistry teaching but also of new biochemists. By putting the student, rather than the information, at the center of the learning process a better-prepared scientist leaves the university ready for the next step.

In the Laboratory

A current wave in teaching biochemistry laboratory focuses on the familiarization of students with those instruments often utilized in research. Although the instruments used in the undergraduate biochemistry laboratory are often less expensive models with fewer features than those used in research laboratories, the technique and theory behind the lesson extend easily to a research or industrial setting. Publications regarding undergraduate biochemistry laboratory experiments can be found in nearly every recent issue of major journals (though they still lag behind the number of publications regarding large introductory lecture chemistry courses), and range from the simple to complex.

An ultraviolet-visible spectrophotometer (UV-Vis) is one of the core instruments of a biochemistry laboratory and works by detecting the absorbance of specific wavelengths of light by a molecule (Bateman & Evans, 1995). Many biological compounds and classes of compounds have unique bands of absorbance, which not only help identify a compound but also lead to the calculation of its concentration—even in a mixture—if that mixture does not contain compounds with similar absorbances. UV-Vis may be used in undergraduate laboratories to assay the kinetics of a glucose oxidase/peroxidase system to demonstrate the concepts of light absorbance, concentration dependence, and coupled enzyme assays in an experiment in which students construct the concepts from gathering and analyzing the data. The same device may be used to demonstrate the effects of substrate concentration, pH, and chemical inhibition on enzyme activity or to measure the binding of avidin to biotin, introducing the concepts of non-covalent interactions and chemical equilibrium, by using the shift in absorbance maximum wavelength of a dye attached to a biotin molecule. In addition to demonstrating the concepts to the students, the avidin-biotin system is a classic example of protein-substrate binding used in biochemistry and immunology classes—by working hands-on with the system, students gain valuable firsthand experience with a concept, which until then was only an example in their text. Firsthand experience is critical in applying the concepts constructively to other protein-substrate systems.

A second critical instrument for a biochemist is the fluorescence spectrometer, which measures light emitted from an excited molecule as the photon returns from the excited to the ground state. Like UV-Vis, fluorescence is unique to certain classes of compounds, or compounds containing certain chemical functional groups, to determine either its concentration or the binding strength of two molecules to each other. Two recent studies use fluorescence techniques to convey complex topics in the laboratory. Fluorescence anisotropy studies of a protein-flavonoid complex may be used to teach students not only the use of fluorescence, but in the information calculated from such data—the dissociation constant for binding and the Gibbs free energy change associated with binding (Ingersoll & Strollo, 2007). Thus their experiment incorporates not only biochemical binding concepts but also thermodynamic energy concepts from physical chemistry to demonstrate the binding. Fluorescence spectroscopy can also determine the concentration of DNA in a solution as well as its native/denatured state ratio (Healy, 2007). The experiment not only examines binding and concentration but also introduces students to statistical Scatchard plots, used widely in binding analysis. Other new methods use circular dichroism spectroscopy, another instrument often found in the laboratory of an industrial or research biochemist, to demonstrate the concept of heat capacity and denaturation of proteins. All of these experiments serve to further decrease the gap in knowledge and experience between the undergraduate and the entry requirements of the graduate/professional student or researcher.

Another focus of new laboratory content is on research-style experiments, which may or may not span several class periods and are often designed in a much more open-ended style than those found in traditional laboratory course books.
These experiments may include a basic procedure but usually leave the data analysis and interpretation to the student, unlike basic "cookbook" laboratory experiments in which a step-by-step walkthrough of the analysis and interpretation is typically included with the laboratory instructions. These new research-style and student-driven experiments often echo the research and investigation style seen in industry and graduate education, with a focus on open-ended, hypothesis-driven experiments. In one experiment undergraduates synthesize chalcones, chemicals often used to fight cancer, and analyze their properties (Dickson et al., 2006). Not only do the students gain instrumental knowledge with infrared, proton-NMR, and UV-Vis spectroscopy, but they also experience cell culture and molecular modeling, enabling them to relate the structure to the function of the synthesized chalcone as well as cutting edge research in a popular field. This type of exercise mirrors those seen in industry and graduate education, and successfully prepares students for a similar environment upon graduation by immersing them in an environment in which information is not distributed but is constructed from available evidence.

More biologically oriented experiments involve the teaching of the techniques involving cell culture, isolation, and purification of molecules. These experiments range from those often seen in research laboratories, in which purification involves a protein to those in government laboratories with purification as part of a forensic investigation (Jackson, Abbey, & Nugent, 2006). In one study, students engage in a 12-session laboratory cycle regarding the study of a protein expressed in nature in Bacillus circulans, wherein students culture and isolate E. coli cells transformed with B. circulans DNA to isolate and analyze a single protein's secondary structure (Russo & Gentile, 2006). Students are not only successful in the aim of the experiment but also more engaged with the science content as a result of the investigative nature of the experiment. In Jackson, Abbey and Nugent's study, students participate in a four-session laboratory cycle in which they harvest cells, extract and amplify DNA, and separate the DNA for a profile via gel electrophoresis. Students exhibit a 100% success rate with the experiment—and it is so popular among the student population that some students not enrolled in the class ask for permission to perform the experiment. Passion of this kind can be growing in departments of humanities and social sciences that some see science departments as lacking. Quite often students will volunteer information about classes they have taken out of interest rather than requirement and most, if not all, are not science courses. As their teachers, we must act to reverse this trend and show undergraduates the sense of astonishment, wonder, and curiosity that continues to drive today's best scientists.

Students can become even more involved in modern experiments, tackling "big picture" concepts as well as teaching techniques. At Arizona State University, students use genetic information to classify the taxonomic relationship between several species of Drosophila (Parker, Ziemb, Cahan, & Rissing, 2004). These students isolate, purify, express, and analyze the DNA of multiple species of Drosophila in the course of their laboratory, sequencing and aligning the DNA and translated protein sequences in order to examine and analyze for differences in the observed patterns. Students use these differences to design a phylogenetic tree, relating five species of Drosophila. Once again, the students are not only successful but also more engaged as a result of this hypothesis- and student-driven approach. Other similar studies focusing on glycobiology and the emerging science of proteomics are successful as well. Some experiments also incorporate literature research and procedure development, further approaching the process utilized by investigators in the field. This type of PBL and technology integration is beginning to infuse chemistry teaching at all levels but particularly with more advanced classes, due to the proximity of the material to current research and the students to the level of a researcher.

INFLUENCE OF TECHNOLOGY

The advent of the digital age mediates every facet of biochemistry education, from planning of lectures to delivery of assessments and grading. Computers and computing devices are integral to biochemists since the digital calculator replaced the slide rule and digital readouts replaced analog measuring devices. However, the meeting of computing technology and the teaching of biochemistry took slightly longer. Modern biochemistry textbooks contain brightly colored, detailed computer-generated renditions of the structures of nucleic acids, proteins, carbohydrates, and lipids, showing their interactions with each other. Teachers lecture with PowerPoint, and students can perform some laboratories entirely on computer. In this section, we examine the rapid development of technology finding a home in biochemistry education.

As biochemistry teaching transitions from the traditional ways of "information delivery" to the constructivist, collaborative methods of today, the rapid development of computer and Internet technology helps to bridge the gap between the student as receiver to an active participant in the learning. In the lecture hall, many teachers use PowerPoint or similar software to deliver their lectures. The use of presentation programs allows instructors to leave the realm of hand-drawn notes and pre-generated transparencies and proceed to the use of computer-generated graphics. Presentations can include three-dimensional representations of molecular structures, animations of reaction mechanisms and binding of complex biological processes, and video clips of reactions in progress, such as ATP synthase. The integration of these representations helps in making biochemistry more tangible to the human mind, helping the students better understand the physical nature of the theory they hear in lecture.

One Internet-based instructional tool is called Chemistry In The News (CIITN). CIITN creates a collaborative learning environment while fostering personal discovery and construction of new knowledge (e.g., Glaser & Carson, 2005). The program consists of students analyzing current news articles relating to developments in scientific research—in Glaser case, organic chemistry, and in Gilmer's case, using the same Web portal, CIITN, but for biochemistry undergraduate classes. In the CIITN projects, the students work in groups searching for, selecting, analyzing, and presenting their analyses of a scientifically relevant and timely arti-
to their peers. Their peers critique and rate each presentation in terms of a rubric. At the end of the semester each student also conducts an intragroup peer review, which can affect the final grades that students get in this required assignment. This type of study not only fosters the sense of community and collaboration that is central and critical to scientific research but also introduces the students to double-blind peer review, in which the both the students writing the reviews and the authors of the COTN post do not the identity of each other. Contrary to the concerns of students, most did well and considered the peer assessment system in organic chemistry to be fair (2.03 on a 1-5 scale with 1 being strongly positive).

Another study Gilmer has undertaken in an undergraduate biochemistry classroom emphasizes students’ uses of Internet technology while they work in collaborative groups, helping them construct meaning in a social constructivist environment (Gilmer, 2004). Students in collaborative groups make presentations on biochemistry topics to the other students and write their understandings on student-constructed websites. Instead of being passive learners, the students need to become active in their learning, utilizing timely data available on the Internet to assess the cutting edge of the field. Students also peer-assess other groups’ presentations, which encourages them to be critical not only of other groups but also of their own group’s presentations.

**CONCLUSIONS**

Biochemistry education is in a state of becoming. It hangs in the balance between the traditional methods in which information is a commodity, presumably transferred in whole units from the teacher to the student using a behaviorist model of learning, and the modern methods in which students actively seek and savor knowledge, instead of the teacher trying to transfer knowledge to the student, using a social constructivist model of learning. In the traditional classrooms, the teacher is the knowledgeable authority and the student presumably a sponge for the information, which the student promptly memorizes and recalls for the examinations, whose scores are the sole determinant and measure of a student’s learning. On the other side of the transition are the newer methods, with the teacher as facilitator of the students’ construction of their own knowledge. In these classrooms and laboratories, the student’s knowledge is longer lasting and viscerally connected via experience to multiple centers of memory and learning. CHAT is a useful lens to look at an undergraduate biochemistry classroom to reduce the contradictions and add to the coherences in the learning environment. The students educated in classrooms on the modern side of the transition state are well prepared, highly educated, self disciplined and motivated. They possess skills vital to their success in future endeavors, be it graduate or professional school, or industrial or governmental careers. Such students become secure with the current literature and standards of biochemical careers, and are comfortable with conducting an independent investigation of biochemical problems while formulating their own conclusions. In such cases, you teach the student “to fish and you feed him for a lifetime.”

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**REFERENCES**


BRATTON, GILMER


