Each year in the United States, an average of more than 200,000 people tear the anterior cruciate ligament (ACL) of the knee.1,2 The majority of these people are active young adults. The ACL and the functions of its anteromedial (AM) and posterolateral (PL) bundles (Figure 1) are a focus of much orthopedic research. This research has revealed that the AM bundle primarily controls anterior movement of the tibia on the femur. By contrast, the PL bundle controls rotational stability of the knee. Jumping, running, pivoting, and twisting—all common movements in such sports as football, soccer, and volleyball—place countervailing demands on both of these bundles.1,6

Without fully functional AM and PL bundles, an individual can incur damage to other support structures of the knee. This realization has led to a developmental interest in double-bundle reconstructions of the ACL.

Studies continue to examine differences between traditional single-bundle repair and newer double-bundle repair with respect to postoperative outcomes and rehabilitation. Systemic reviews have consistently shown that single-bundle repair is a safe surgical procedure with reliable results.7,8 Systemic reviews have also led to the conclusion that postoperative anterior and rotational stability may be improved with...
double-bundle repair, though other clinical outcomes appear to be similar with the single-bundle and double-bundle techniques.1,3–8

Dependant factors, including available healthcare resources and patient age, functionality, and comorbidities, contribute to the selection of single-bundle vs double-bundle repairs. In either case, understanding the kinematic roles of the bundles can be an effective tool for developing the proper surgical procedure to fit each patient’s needs.1,7,8

Although a clear understanding of AM and PL bundle function is essential for effective diagnosis and treatment of patients with ACL injuries, a review of the literature (using the National Library of Medicine’s PubMed database and the following keywords: anterior cruciate ligament; anterior cruciate ligament function; anterior cruciate ligament and osteopathic medical education; anteromedial and posterolateral bundles) suggests that basic science curricula at most medical schools include only limited discussion of these bundles. However, there has been a recent movement toward curricular reform of musculoskeletal instruction in medical education.9,10 In the present article, we have attempted to assess the degree to which the AM and PL bundles are discussed in basic science curricula at colleges of osteopathic medicine (COMs) in the United States.

Methods
In September 2008, a survey was mailed to all (at that time) 28 COMs, including branch campuses, accredited by the American Osteopathic Association’s Commission on Osteopathic College Accreditation. First, each COM was contacted and the individual in charge of presenting lower extremity anatomy instruction to osteopathic medical students was identified. The survey was then sent to the identified instructor at each institution, who was given 8 weeks to return the completed survey. The intent of this survey was to evaluate instruction in functional anatomy of the AM and PL bundles of the ACL within the basic science curricula of the COMs.

The questionnaire consisted of 6 multiple choice or yes/no questions. The first question asked whether the AM and PL bundle anatomy of the ACL was covered within lectures, case reviews, discussion groups, or any other form of instruction (eg, laboratories) given to osteopathic medical students. This question also requested an estimation of hours spent on this subject matter via any of these instructional methods, as well as any additional comments the instructors wanted to share.

The next 4 questions asked the instructors to evaluate which aspects of the AM and PL bundles are addressed at their COMs. First, faculty were asked to note if osteopathic medical students are informed that the position of the bundles change from a crossed state in flexion to a parallel state in extension. The faculty were then asked if students are instructed on the kinematic contribution of the AM bundle to the restriction of anterior-posterior motion at the knee and on the kinematic contribution of the PL bundle as the main rotational stabilizer of the knee. A further question was posed asking if students are ever required to identify the AM and PL bundles through direct visualization during gross anatomic dissection of the ACL.

The final question of the survey asked instructors to evaluate how important they felt the AM and PL bundles are within the basic science curricula of ACL biomechanics. They were asked to rate this importance using a Likert scale ranging from 5 (very important) to 1 (not important).

Prior to the survey distribution for the actual study, content validity of the survey was assessed using a β-test in which surveys were distributed to various faculty at the Kansas City University of Medicine and Biosciences (KCUMB) in Missouri. Five surveys were distributed to basic science and clinical professors, 2 surveys were sent to sports medicine osteopathic physicians, 2 surveys were sent to gross anatomists, and 1 survey was sent to a senior member of the KCUMB Division of Research. Suggestions and edits were requested from each member of the β-test group, and the survey was adjusted accordingly. The KCUMB Institutional Review Board approved the present study.

Results
Twenty-one of the 28 COMs (75.0%) returned responses to the survey. Of these 21 institutions, 9 COMs (42.9%) indicated that both the AM and PL bundles of the ACL are discussed within their basic science curricula. The other 12 responding schools (57.1%) indicated that this material is not covered within their basic science curricula (Figure 2).

Of the 9 COMs in which the AM and PL bundles are discussed, 7 responded that they address the bundles during lectures, 3 responded that they address the bundles during laboratories, and 1 responded that it covers the bundles in a case review format (Figure 3).

Four of the 21 responding COMs (19.1%)—ie, 4 of the 9 COMs in which AM and PL bundles are discussed—indicated that they instruct students that the bundles are parallel in extension and crossed in flexion (Figure 4). Nine of the 21 responding COMs (42.9%) reported that they instruct students that the AM bundle is a major anterior-posterior restrictor, and 12 (57.1%) reported that they instruct students on the kinematic contribution of the PL as the major rotational stabilizer of the ACL (Figure 4). One of the 21 responding COMs (4.8%) indicated that it exclusively addresses the anterior-posterior stabilization component, and 2 (9.5%) indicated that they exclusively discuss the rotational stabilization component. Seven of the responding schools (33.3%) reported that students identify the AM and PL bundles via direct visualization during anatomic dissection of the ACL.

The Likert scale results of the survey yielded 13 responses (61.9%) indicating that the clinical significance of the AM and PL bundles in basic science education is not important or
slightly important, and 7 responses (33.3\%) indicating that the clinical significance of the bundles is average, important, or very important. One responding COM (4.8\%) did not complete the Likert scale portion of the survey.

Comment
In a report published in 2005 by the Association of American Medical Colleges, the authors emphasized that medical students should be instructed in understanding and assessing common joint injuries, including injuries of the ACL. The report suggests the need for a multidisciplinary approach, including hands-on learning paired with a curriculum correlating structure and function as tools for physical diagnosis.\(^1\)

At COMs, a template for this concept could consist of direct visualization and hands-on dissection of the ACL in gross anatomy laboratories, coupled with lectures and instruction in osteopathic manipulative treatment to correlate the structure and function of the AM and PL bundles as they relate to the diagnosis of ACL injuries.

Our survey results revealed that more than half of the responding COMs do not address the AM and PL bundles within their basic science curricula. Of those COMs that do address this subject matter, more than half of the schools discuss the functional aspects of the ACL. Several of the schools that discuss the functional aspects of the ACL choose not to address the contributions of both the AM and PL components. Interestingly, a small subset of COMs address only the PL component in regard to rotational stability. We do not address the function of the AM bundle as a stabilizer of anterior-posterior translational motion of the knee. It is possible that this function of the AM bundle is discussed in the context of the ACL as a whole, though we did not assess that possibility with our survey.

With regard to the Likert scale, the survey revealed an interesting dichotomy in responses. Approximately half of the responding COM instructors feel that instruction in the AM and PL bundles is not important, whereas the other half feel that this instruction is important. This inconsistency may illustrate a paradigm shift in curricular education at COMs toward a more comprehensive focus on function as well as structure. However, COM instructors would need to be asked additional questions about curricular instruction in ACL function to clarify the reasons for this dichotomy.

Osteopathic assessment of the ACL using standardized physical examination can be enhanced if the osteopathic medical student is given a clear understanding of the relationship between the functional bundle and a specific diagnostic test. For example, the pivot shift test assesses primarily the rotational component of the ACL encompassed within the PL bundle. By contrast, the anterior drawer test and the Lachman maneuver are better suited for assessing AM bundle compromise of stability and tension when the leg is placed in full extension.\(^2\) It is difficult to become adept at the subtleties of ACL assessment, and an osteopathic physician in training can benefit from a mindful understanding of ACL bundle function in an insufficient knee.

In recent decades, there has been a trend toward the presentation of clinically relevant material in anatomy classes, and this type of instruction has become a standard in osteopathic medical education.\(^3\)-\(^6\) Of those COMs in which the AM and PL bundles are discussed, according to our survey results, one-third of the schools instruct their students to dissect and visualize both components of the ACL in the laboratory setting. Gross anatomic dissection at COMs is often designed to teach clinically and surgically relevant anatomy to osteopathic medical students. To understand the dynamic architecture of the knee joint and the kinematic contributions of the ACL, bundle identification in a laboratory setting can be a helpful tool. Dissection laboratory can stimulate visual and tactile learning, allowing students to conceptualize the 3-dimensional structure of the ACL. In addition, a demonstration of a tear in one of the bundles can reveal the functional instability that it induces.

With approximately 200,000 ACL injuries occurring each year in the United States—75\% of which require surgical restoration\(^1\) it is likely that osteopathic medical students will encounter this injury during their third-year and fourth-year rotations. In order to understand and diagnose the deficits

Figure 2. Responses of instructors at colleges of osteopathic medicine (COMs) to survey question on whether the anatomy of the anterior cruciate ligament (ACL) is covered in any category of the basic science curricula at the COMs (N=21).
of an ACL injury, students must first understand the functions of the ACL. Introducing the functional importance of the AM and PL bundles of the ACL in laboratory and lecture during a student’s first 2 years of medical education should prove useful during subsequent training.

Conclusion
The present survey results reveal a void in anatomic instruction regarding the AM and PL bundles of the ACL within osteopathic medical education. Because of the probability that third-year and fourth-year osteopathic medical students will encounter ACL injuries during their clinical rotations, it is of paramount importance that students fully understand the functions of the ACL to ensure effective use of osteopathic diagnostic techniques. This understanding, in turn, requires an understanding of AM and PL bundles as 2 distinct functional components of the ACL.

Our findings suggest the need for enhanced presentation of the AM and PL bundles within the basic science curricula at COMs, thereby providing a more comprehensive anatomic education for osteopathic medical students.

References