The purpose of this study was to determine whether, in comparison with naive students, experienced students who have completed an elementary physiology course 1) have a greater knowledge level of physiology and 2) perform better in an upper division physiology course. The educational setting for this study was the cardiovascular block of an advanced undergraduate level course entitled Principles of Human Physiology (PGY 412). The study employed students who had completed elementary physiology (PGY 206) at the University of Kentucky (group 1), students who had completed elementary physiology in another academic program (group 2), and naive students with no prior physiology experience (group 3). A cardiovascular pretest was presented during the opening session of the cardiovascular block in PGY 412. Respective scores for the three groups were 29.4%, 31.7%, and 24.1%, and there were no significant between-group differences. Respective scores on the same pretest items given as a posttest at the end of the cardiovascular block were 90.4%, 91.4%, and 90.4% and, again, there were no significant between-group differences. Respective scores on other cardiovascular test items given at the end of the block were 78.9%, 78.7%, and 81.1%. Interestingly, the highest score here was achieved by the naive students (group 3), but, once again, between-group differences were not significant. In summary, on the basis of pretest/posttest examination of cardiovascular physiology between naive and experienced students, the results of this study indicate 1) that the common assumption that students entering advanced level physiology courses have a significant retention of knowledge from elementary physiology is not valid and 2) that completion of an elementary physiology course does not offer an advantage in learning advanced material.
students possessed before entering a variety of physiology courses. These results question the long-standing assumption that prerequisite knowledge is beneficial, if not necessary, for students to master more advanced course content. Along these lines, the purpose of the present study was to test the following hypotheses: 1) in comparison with naive students, experienced students who have completed an elementary physiology course have a greater knowledge level of basic physiology at the start of an advanced course; and 2) experienced students perform better than naive students in an upper division physiology course.

METHODS

Educational setting. The educational setting for this study was a one-semester, four-credit hour, lecture-based advanced undergraduate course, entitled Principles of Human Physiology (PGY 412), administered by the Department of Physiology at the University of Kentucky. The enrollment of PGY 412 ranges from 80 to 120 students per semester, the majority of whom are in the College of Allied Health Professions. Specific degree programs of these students include Physical Therapy, Physician’s Assistant, and Clinical Nutrition. In addition to the Allied Health students, 10–15% of the students are in the Masters of Nursing program, whereas a smaller number, 5%, are unspecified as to a degree program.

The listed prerequisite for PGY 412 is Elementary Physiology (PGY 206), also administered by the Department of Physiology at Kentucky, or an equivalent course taken elsewhere. However, because PGY 412 is a component of the aforementioned Allied Health programs, students within these programs may enroll in PGY 412 without having taken a previous college-level physiology course. Thus, with regard to prerequisite experience, PGY 412 contained three categories of students that comprised the groups for the present study: 1) experienced students who had taken PGY 206 at the University of Kentucky, 2) experienced students who had completed an equivalent elementary physiology course elsewhere, and 3) naive students who had not completed an elementary physiology course.

During the academic term in which the present project took place, there were 96 students enrolled in PGY 412. Of these students, 21 had taken PGY 206 at the University of Kentucky (group 1: PGY 206), whereas 41 had taken an elementary physiology course elsewhere (group 2: other PGY), and 34 had no previous college-level physiology (group 3: no PGY).

PGY 412 is a team-taught course in which I presented the cardiovascular block for the classes represented in this study. In addition, I am the only member of the PGY 412 team to also teach Elementary Physiology (PGY 206). Accordingly, the present study was confined to the cardiovascular system because this was the only subject for which pretest items (see Cardiovascular pretest) could be directly matched to topics that had been presented in PGY 206 and that would be presented in PGY 412.

Cardiovascular pretest. To determine the entry level of cardiovascular knowledge of the PGY 412 students, a pretest consisting of eight multiple-choice questions based on cardiovascular material presented in our elementary physiology course (PGY 206) was administered during the opening lecture of the cardiovascular block. Because the pretest would not be used in determining final grades in PGY 412, the pretest document did not contain student identifiers other than background information on previous physiology courses (e.g., PGY 206, another elementary physiology course, or no previous physiology).

The items comprising the pretest are presented in Table 1. The first three questions are factual recall and correspond to level one of Crooks’ question item taxonomy (1). The remaining five questions require some integration of lecture material. These correspond to Crooks’ second level of item taxonomy, comprehension/application (1). For example, in question 4 students must comprehend the control of arterial blood pressure, including the role of heart rate. With this as a framework they must apply the facts that the vagus nerve carries parasympathetic innervation to the heart and that parasympathetic activity reduces heart rate. The proportion of questions in the pretest requiring factual recall to those requiring integration of material is reflective of the emphasis on comprehension and application used in the cardiovascular section of PGY 412.
Cardiovascular posttest. To determine the students' knowledge gain, the same eight pretest questions were given at the end of the cardiovascular block within the context of a larger examination containing additional cardiovascular questions. Performance of the three student groups on the pre- and posttest questions and on new cardiovascular questions were recorded for subsequent analysis.

Data analysis. Because the pretest did not contain student identifiers, the use of a repeated-measures ANOVA was precluded in comparing pre- and posttest results. Accordingly, a one-way ANOVA was used to compare pre- and posttest scores across the three groups of students, whereas the independent t-test was used for comparisons within a group (e.g., pre- vs. posttest). Because the study consisted of three groups, the maximal probability level for significant t values was reduced to P < 0.017 in accordance with the Bonferroni correction (7).

RESULTS

Table 2 presents mean pretest scores for the three groups. Although scores for the experienced students who had taken elementary physiology (groups 1 and 2) were slightly higher than those for the naive students with no previous physiology course work (group 3), all pretest scores were quite low, and there were no significant between-group differences. Furthermore, pooling groups 1 and 2 (i.e., experienced students) and then comparing these results with those for group 3 (i.e., naive students) by independent t-test also showed no significant between-group difference (P > 0.087).

Table 3 presents posttest results. The first row in Table 3 gives percent correct responses for the same items presented earlier in the pretest; whereas the second row gives the scores on all other cardiovascular posttest questions and on new cardiovascular questions were recorded for subsequent analysis.

Correct responses are represented in boldface.

### Table 1
Principles of Human Physiology (PGY 412):
cardiovascular pretest

<p>| | | |</p>
<table>
<thead>
<tr>
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</table>
| 1 | Starling's law of the heart refers to the relationship between:  
   A. central venous pressure and stroke volume  
   B. heart rate and cardiac output  
   C. blood pressure and vascular resistance  
   D. cardiac muscle action potentials and the electrocardiogram (ECG) |
| 2 | Which of the following components of the ECG represents ventricular depolarization?  
   A. The P wave  
   B. the QRS complex  
   C. The T wave |
| 3 | Which of the following is the preload on the heart?  
   A. total peripheral vascular resistance  
   B. end systolic volume of the heart  
   C. arterial blood pressure  
   D. end-diastolic volume of the heart |
| 4 | A massive stimulation of the vagus nerve to the heart will cause a decrease in arterial blood pressure due to a decrease in:  
   A. heart rate  
   B. total peripheral vascular resistance  
   C. vascular compliance  
   D. stroke volume |
| 5 | A massive reduction in the activity of sympathetic innervation to blood vessels will cause a decrease in arterial blood pressure due to a decrease in:  
   A. heart rate  
   B. total peripheral vascular resistance  
   C. vascular compliance  
   D. stroke volume |
| 6 | Which of the following would be a potential cardiovascular side effect of atropine, a drug used to block cholinergic receptors?  
   A. hypotension  
   B. tachycardia  
   C. reduced contractile force of the heart  
   D. peripheral edema |
| 7 | Dilation of arterioles supplying blood to a tissue will lead to an increase in interstitial fluid in the tissue (edema). Which of the following causes this to occur?  
   A. an increase in colloid osmotic pressure of blood plasma  
   B. a reduction in lymph vessel contractions  
   C. an increase in capillary blood pressure  
   D. an increase in capillary permeability |
| 8 | Reduction of plasma volume during states of dehydration, as would occur when sweating, is minimized because fluid is absorbed from the interstitium into the blood. An increase in which of the following causes this to occur?  
   A. colloid osmotic pressure of the interstitial fluid  
   B. hydrostatic pressure in the interstitial fluid  
   C. colloid osmotic pressure of blood plasma  
   D. capillary blood pressure |

Correct responses are represented in boldface.
lar questions in the examination given at the end of the cardiovascular block. As expected, all groups scored significantly higher on pretest items that were repeated in the posttest. Furthermore, all groups scored significantly higher on the repeated items compared with other cardiovascular questions. However, there were no significant between-group differences for either repeated or new questions.

**DISCUSSION**

This study sought to determine whether students who had completed an elementary physiology course would have a greater knowledge level of physiology and would perform better in an upper division course compared with naive students who had not had prior physiology exposure. The upper division course used for this study, PGY 412, is team taught, and, for reasons explained in the introduction, the scope of the study was limited to the cardiovascular block of the course. Furthermore, for reasons of confidentiality, students were asked to give only their level of physiology experience on the pre- and posttest instruments. No other identifiers were used. Accordingly, this limited the study to a one-way ANOVA of pre- and posttests of cardiovascular knowledge.

Notwithstanding the limitations of the present study, the results indicate that completion of a college-level elementary physiology course does not necessarily bolster student performance in an advanced course. In fact, naive students in this study (group 3) scored just as well as experienced students (groups 1 and 2) on both repeat and new items in the posttest given at the end of the cardiovascular block (Table 3).

The observation that pretest scores for the experienced students were quite low and not significantly different from the naive students (Table 2) indicates that the former groups, although exposed to knowledge of the cardiovascular system in elementary courses, did not learn the subject well enough to form cognitive models that foster retention of information. Analysis of possible reasons for this is beyond the scope of the present study; however, the low retention of the experienced students probably relates to passive didactic lecturing being the dominant teaching method in elementary physiology courses, as observed by Rovick (personal communication) and colleagues in their study (6). In this context, it is generally held that students have better retention of knowledge when taught by active, as opposed to passive, methods (2–4). On this point, 6 of the 21 students in group 1 (PGY 206) did have some active learning components in their elementary physiology course (5), and these students had higher pretest scores in the present study (37.8%) compared with the 15 other 206 students who had didactic lectures only (26.1%) in their elementary physiology course. These findings are consistent with the notion that active learning improves retention; however, because of the large difference in the number of subjects, these two subgroups are not statistically comparable.

The advanced level course that formed the setting for the present study (PGY 412) covers the same material as does our elementary physiology course (PGY 206) but at a much faster pace and with more breadth as well as depth. The fact that both naive and experienced students scored basically the same on cardiovascular material presented in PGY 412 (Table 3) clearly indicates that completion of an elementary course is not necessary for students to learn the content of a more in-depth and fast-paced advanced course. This does not mean that students in advanced physiology courses who have good retention of their elementary physiology would not do better than naive students, only that, as indicated by cardiovascular test results, the simple completion of an elementary physiology course does not, of itself, offer an advantage in an advanced course.

In summary, with regard to prerequisites, the study by Rovick et al. (6) showed that assumptions about

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**TABLE 3**

**Posttest scores**

<table>
<thead>
<tr>
<th>Group</th>
<th>Score, %correct response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: PGY 206</td>
<td>90.4*†</td>
</tr>
<tr>
<td>2: Other PGY</td>
<td>91.4*†</td>
</tr>
<tr>
<td>3: No PGY</td>
<td>90.4*†</td>
</tr>
</tbody>
</table>

Score, %correct response

<table>
<thead>
<tr>
<th></th>
<th>78.9</th>
<th>78.7</th>
<th>81.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same questions as pretest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All other cardiovascular questions</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There are no significant between-group differences (P > 0.61).
*Significantly different from pretest score (P < 0.0001; see Table 1).
†Significantly different from score for all other cardiovascular questions (P < 0.007).
students' background knowledge of science before entering physiology courses are not valid. The present study showed that the assumption that students entering advanced physiology courses have a significant retention of knowledge from elementary physiology is also not valid. These observations question the course prerequisite policies of most colleges and universities, which assume the retention of more background knowledge than may be present.

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