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An Anatomy Based Health Education Curriculum Taught by Medical Students May Improve High School Students Health Knowledge

Jason Knight

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An Anatomy Based Health Education Curriculum
Taught by Medical Students
May Improve High School Students’ Health Knowledge

A Thesis Submitted to the
Yale University School of Medicine
in Partial Fulfillment of the Requirements for the
Degree of Doctor of Medicine

by
Jason Anthony Knight
2006
ABSTRACT

To date, few high school based interventions have been shown to have lasting effects on adolescents' health behaviors. The need for health interventions targeting adolescents is underscored by data showing that several health behaviors with significant short and long term adverse effects begin in early adolescence and become progressively more prevalent toward late adolescence. This project tested the efficacy of a novel anatomy based health education curriculum at increasing health knowledge. The course was taught by first year Yale medical students. The curriculum placed emphasis on nutrition, physical activity and infectious disease. Forty Juniors from Career High School visited Yale's anatomy lab once every two weeks for ten hour-long sessions. In addition to visits to the anatomy lab, students completed two class projects, one covered nutrition and the other focused on exercise. Four additional sessions at Career High School were dedicated to the class projects. Pre and post test analysis showed an improvement in health knowledge with a thirteen percentage point improvement on a standardized health knowledge survey. The students' performance was compared to a control cohort of thirty-one students who were not exposed to the curriculum. Students exposed to the curriculum had a nineteen percentage point advantage compared to control students who had not been exposed. Curriculum efficacy as demonstrated by this small cohort validate further testing with larger cohorts and more vigorous controls as well as separate testing to measure changes in health behavior attributable to curriculum exposure.
This project is dedicated to the students of Career High School who have been a constant source of inspiration.

Special thanks to the following people, without whom, this project would not have been possible:
Shirley Neighbors
Michael Cerraso
Rose Coggins
First Year Medical Student Instructors
Bill Stewart, PhD
Woody Lee, MD

Funding for this project was granted through the Pfeiffer Research Fellowship, an initiative of The Office of Multicultural Affairs, Yale School of Medicine.
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INTRODUCTION

Inspiration

The road that led me to this project was by no means direct, and although I did not know it at the time, the experiences that shaped my approach to education and nurtured my curiosity about how students learn began in high school. A popular misconception about educating is that there are two types of teachers: those that have a natural gift for teaching and those that don’t. While this oversimplification makes it easy for us to look back at our experiences as students and applaud our more revered teachers as bearers of pedagogical genius, it obfuscates the essence of good teaching: effective communication, where one’s ability to actively listen is as important as one’s ability to speak. Essentially, anyone can be an excellent teacher if they are willing to be students in effective communication.

My bad habit of falling asleep in class began as a high school freshman. While my propensity to fall asleep in class has not changed, my viewpoint on the phenomenon changed dramatically after a yearlong experience as a high school teacher of biology and chemistry in a New York Public School in 2000/2001. What I once viewed as a student’s bad habit, I now view as a teacher’s bad habit. A sleeping student is the sentinel sign of a teacher failing the most basic tenet of effective communication: engage your audience. Failure to engage an audience is a common failure, as it is far easier to speak at your audience than speak with your audience. The latter is akin to a conversation and requires one to invest energy to observe and listen to the audience in real-time, and then plan an appropriate verbal response. I am confident that most of us can testify to the power of conversant teaching. I can remember several lectures during my first year of medical school, where despite my sleep deprived state, nodding off never occurred to me as an option because I was so thoroughly engaged by the professor’s dialogue.
This and several other pedagogical editorials I had categorized in my mind as insignificant ideologic remnants of my short lived teaching career until I had the happenstance, as a first year student, to observe a group of high school students tour the lab while I was reviewing my dissection at another table. The group of about twenty students was divided into four small groups, each led by one of my peers. I was immediately intrigued by the dynamic interaction that the high school students had with their medical student guides. Seeing the contents of a body before them sparked a litany of questions that fueled an hour long dialogue between the students and their medical student teachers. Simple “what” questions (eg, “What’s this?”) quickly led to “how” and “why” questions—questions which are the fundamental tools by which students translate factual knowledge into concepts with practical application. Falling asleep wasn’t an option for these students because they were in the driver’s seat. Their motivation was of the purest form: sincere curiosity and fascination with what was before them—a human body, much like their own.

It was apparent that learning was taking place and at a degree of depth and sophistication that I had never seen in a classroom; but the lack of a central theme guiding the learning experience translated into students asking questions that often took the discussion in divergent directions. In a similar fashion, the medical students who were so happy to be asked questions to which they knew the answers, failed to appreciate the importance of organizing their responses in a way that helped their audience place the information into a useable framework. The result was a learning experience that was incomplete and haphazard.

It was clear that standing over a cadaver, the high school students were awash in information and mesmerized by its realness. Think back to your first day in the anatomy lab. Their questions were evidence that they didn’t know where to begin. Lacking perspective, their minds danced unknowingly among topics whose depth they could not appreciate, as their eyes passed over entire
organ systems with no appreciation for the vital distinctions that separate them, or the relationships
that bind them together. Although, in the visit, I observed problems with the way information was
being organized, the most essential condition for learning was already being met: the teachers were
actively listening to their students and their responses to questions engaged their audience. In that
moment I saw an opportunity to teach.

The next day I approached Bill Stewart, Professor of Anatomy and hero to every first year medical
student. I asked him about the visit I had observed the day prior and he told me that it was part of the
Anatomy Teaching Program (ATP). The program was in its ninth year and was born out of an
informal collaboration between Dr. Stewart and Shirley Neighbors, a veteran anatomy teacher at
Career High School whose campus is three blocks from our medical school. At its inception, the
program, then without a name, was an opportunity for Mrs. Neighbors to escape the confines of the
idealized drawings and models she used in her classroom and show her students a dimension of
anatomy that heretofore was not available. Bringing her students to see a cadaver allowed them the
perspective to see organ systems not as isolated entities unto themselves, but as part of a larger unit
where even the smallest function happens concurrently with a multitude of others.

What began as one-time sessions evolved into regularly scheduled visits. With that, Dr. Stewart saw
an opportunity for first year medical students to review their dissections in a more macroscopic way.
By having medical students lead the sessions with Mrs. Neighbors’ students, the medical students had
a rare opportunity to take a step back and view their cadavers as the sum of its parts. With the
addition of medical students, the Anatomy Teaching Program was born. It was an informal program
with no well defined teaching objectives and no formal assessments; merely a way for both Mrs.
Neighbors and Dr. Stewart to offer their students a dimension of perspective that they may not
otherwise have had from their respective courses.
In our discussion I mentioned how I was inspired by what I observed as an ideal student-teacher interaction, but noted a lack of direction in the discussions Mrs. Neighbors’ students were having with the medical students. We agreed that in the visits we saw high school students who were motivated by the experience beyond levels we had seen in a classroom. Such moments of intense motivation are rare moments to teach. I proposed that I develop a curriculum that would harness this motivation—providing the medical students with objectives for each session that would focus their discussions with students. In addition, the high school students would receive a packet before each lesson that would introduce the theme for the next visit. The packets would cover basic medical vocabulary they are likely to hear used by the medical students, and provide basic medical problems that I hoped would spawn questions to drive each lesson. Dr. Stewart endorsed the idea immediately and we met with administrators at Career High School to brainstorm what the agenda of this new ATP curriculum should be.

Rose Coggins, Principal of Career High School along with the heads of the science departments were unanimous in their belief that an ATP curriculum whose focus was improving student’s attitudes toward healthy behavior would be the best use of my time. We agreed that the curriculum should not use as its device, shock-value stunts akin to the “This is your brain; This is your brain on drugs” approach, championed by Public Service Announcements in the 80s touting that unforgettable hook. Instead, the curriculum should give students a realistic appreciation for the spectrum of the human condition from health to disease, with emphasis on behaviors that mediate this continuum.

After this meeting, Dr. Stewart and I saw that we had the beginning of a study—a controlled trial that would compare the efficacy of my new health curriculum with the existing health curriculum that was already in place. In fact, I learned from subsequent discussion with Mrs. Coggins, that a formal health education curriculum does not exist at Career High School, nor is there any requirement that students take a health related course. This underscored, in my mind, the utility of developing this
curriculum. If successful, Mrs. Coggins would like to make this course available to the entire Junior class at Career.

From the standpoint of school based health curricula/interventions, this curriculum, that uses gross anatomy as a starting point to educate students about health, embodies an approach that has never been tried before. While this was a great advantage from a scientific standpoint, it proved to be my greatest liability in terms of garnering support, both from the non-science administrators at Career as well as from sources of funding. Among educators, telling them that I planned to design a novel health education curriculum drew immediate interest as the milestone of developing a health education curriculum with measurable and sustained positive impact on health behavior has yet to be reached. But when I explained that my proposed teaching model will use cadavers in the delivery of content, educators’ interest in my program sublimated into outright opposition.

New ideas are always the hardest to implement because they often challenge the status quo. In my case, my proposal not only challenged the standard approach to health education but challenged taboos regarding dead bodies and social norms about what is appropriate for high-school-aged students. With these obstacles ahead of me and others that will be discussed in detail later, my objective was to aim for something attainable. A pilot study was the best I could hope for. Its small size coupled with a compromise whereby I agreed to limit subjects to students who elected to take Mrs. Neighbors’ anatomy class allayed the concerns of administrators who initially were opposed to the idea. While many of the compromises that had to be made imposed limitations on this project, I view this endeavor not as a definitive answer to a research question, but instead as the first step in exploring a technique that has not been tried before. My results provide the necessary evidence to argue that such exploration is warranted; and it provides the power to confront opponents with fact rather than supposition.
Local and national trends in risk behavior among high school adolescents

*Using behavior trends to design health interventions*

When developing a health education curriculum, an understanding of the target population is important. An intervention is more likely to be successful if it addresses, in a culturally appropriate way, the unique health needs of the target community. This insight requires an analysis of the target population to determine, among other things, their present health status, prevalent risk behaviors, belief systems; racial, cultural, social and economic demographics, education level and obstacles to improved behavior.

A health intervention has the highest likelihood of having a measurable impact if several criteria are met:

- Intervention targets risk behavior(s) that are prevalent
- Targeted risk behaviors have measurable consequences
- Intervention addresses obstacles to behavior change
- Intervention provides social support

The first two criteria will be discussed here, the later two will be discussed in the methods section under “Curriculum Design”. Identifying prevalent risk behaviors is made possible using local and national databases of adolescent risk behaviors. The Youth Risk Behavior Surveillance System (YRBSS) is a project managed by the Centers for Disease Control and Prevention (CDC). Beginning in 1991, the CDC has compiled an exhaustive database of risk behaviors using semiannual surveys of high school aged adolescents in the 50 states and the District of Columbia. Results from the YRBSS have been used by health and education officials to identify problematic behavior trends and tailor appropriate interventions.
The YRBSS consists of an eighty-seven item multiple choice survey that covers six topics:

- unintentional injuries and violence
- tobacco use
- alcohol and drug use
- sexual behavior
- dietary habits
- physical activity

The survey is administered nationally every two years by the CDC to 9th, 10th, 11th and 12th grade students. For each of the sample years: 1999, 2001 and 2003, the YRBSS analyzed between 13,601 and 15,349 surveys collected from over 140 schools nationwide. In addition to the CDC administered surveys, local health and education officials can add or delete items from the national survey to design a focused survey to answer a specific local interest. Where applicable, this data is included in the YRBSS database.

The most powerful analysis of the YRBSS data set is achieved when data from across the nation is pooled to create a national picture of youth behavior trends. For several behavior patterns, the volume of data is robust enough to provide regional trends in risk behavior. I have included risk behavior trends for Connecticut where available from the YRBSS dataset. The primary limitation of regional analysis is that the power to compare plot risk behavior trends between subsets of respondents with specific attributes (such as race and gender) is lost. For example, the national YRBSS analysis contains enough data to allow meaningful comparisons of gender variation of smoking behavior among member of the same race and age. Regional analysis of the data specific to
Connecticut is robust enough to detect differences in smoking patterns between genders, but only when all races and ages are pooled.

Unfortunately, the most recent regional data for Connecticut is dated 1997. Obviously, this data is not sufficient to describe, with certainty, current behavior trends among adolescents within the state. I have included the data so that the reader may get a general idea of how the national behavior trends compare to trends in Connecticut. I am hoping that the reader will agree that for the most part, adolescents in Connecticut appear, based on 1997 statistics, to engage in patterns of risky behavior that are similar to national statistics. Based on this similarity, I used the more up-to-date national data set as a loose proxy for current regional behavior when identifying behaviors that were addressed in the curriculum that I designed.

The tables on the following pages summarize risk behavior trends between 1997 and 2003 using the national YRBSS data analysis and regional analysis where available.\textsuperscript{1,4,6-8}

\textit{Trends in physical activity and overweight}

YRBSS and National Health and Nutrition Examination Survey (NHES) data shows that over the last twelve years adolescent obesity has been steadily increasing across the nation with a disproportionate increase in overweight among black and Hispanic youth compared to white youth.\textsuperscript{1,4,9} In 2003, 13.5% (CI\textsuperscript{†} ±1.3%) of high school adolescents met the criteria for overweight (BMI \geq 95\textsuperscript{th} percentile), and an additional 15.4% of adolescents were at risk for overweight (BMI \geq 85\textsuperscript{th} percentile < 95\textsuperscript{th} percentile).\textsuperscript{4} In 1999 and 2001, national overweight prevalence was 10.8% (CI ±1.2%) and 10.5% (CI ±1.2%) respectively.\textsuperscript{1} Prevalence of risk for overweight during the same time period was 14.3% (CI ±1.0%) and 13.6% (CI ±0.8%) respectively.\textsuperscript{1}

\textsuperscript{†} Confidence Interval
Between 1999 and 2003, the increased prevalence of overweight was modest, from 10.8% to 13.5%. During the same interval, the increased prevalence of adolescents at risk of overweight was not statistically significant. However, when observing the prevalence of overweight among black and Hispanic youth, the increase is more remarkable. For sample years 1999, 2001 and 2003, the prevalence of overweight among black youth was 10.2% (CI ±1.9%), 16.0% (CI ±2.4%) and 16.2% (CI ±1.4%) respectively. During the same interval, the prevalence of overweight among Hispanics was 13.6% (CI ±2.3%), 15.1% (CI ±2.8%) and 16.4% (CI 2.5%). The prevalence of overweight among white children while remarkable, it is not observed to increase appreciably. Prevalence of overweight among white youth for sample years 1999, 2001 and 2003 are: 10.2% (CI ±1.9%), 8.8% (CI ±1.0%) and 10.4% (CI ±1.8%) respectively.

Because the overweight data in the YRBSS is based on BMIs calculated from self-reported heights and weights without actual measurements, it is important to correlate the YRBSS findings with more quantitative studies. The NHES has been recording adolescent height and weights using objective standardized measurements from national samples since 1963. During the NHES interval that most closely matches the YRBSS interval (NHES time points being “1988-1994” and “1999-2000”), NHES documented an overall increase in overweight of 5% (p < 0.001). Among black youth, the NHES documented a comparative increase in overweight of 10% (p < 0.001) between the same intervals. Increasing amounts of data are pointing to a disproportionate increase in the prevalence of overweight among minority communities.

The prevalence of overweight is paralleled by a significant prevalence of inadequate physical activity (Table 1). Physical inactivity, when combined with a calorie dense diet, contributes to developing overweight. In 2003, YRBSS data indicated that 33.4% (CI ±2.1%) of adolescents reported
inadequate physical activity\(^\dagger\). Interestingly, 28.9% of adolescents are either overweight or at risk for overweight. While the data is not available from the YRBSS to determine if self reported inactivity positively correlated with overweight or at risk for overweight, the correlation is far from unimaginable. Because the intervention described in this thesis targets a predominantly black and Hispanic community, it is noteworthy that the highest prevalence of overweight, at risk for overweight and insufficient physical activity are observed in black and Hispanic adolescents compared to whites.

### Table 1

<table>
<thead>
<tr>
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<th>1997</th>
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<th>2001</th>
<th>2003</th>
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<td>CT</td>
<td>Nat'l</td>
<td>Nat'l</td>
<td>Nat'l</td>
</tr>
<tr>
<td>Hispanic</td>
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<tr>
<td>Total</td>
<td>41.2 (±9.8)</td>
<td>35.2(±4.3)</td>
<td>35.4(±2.8)</td>
<td>36.5(±2.8)</td>
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<td>Male</td>
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<td>27.7(±3.1)</td>
<td>30.3(±3.8)</td>
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<td>Female</td>
<td>45.8(±5.1)</td>
<td>43.0(±4.3)</td>
<td>42.6(±4.5)</td>
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<tr>
<td>White</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>33.3(±3.3)</td>
<td>28.2(±2.2)</td>
<td>29.3(±1.7)</td>
<td>31.0(±2.9)</td>
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<tr>
<td>Male</td>
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<td>21.9(±3.8)</td>
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<td>34.8(±2.5)</td>
<td>35.3(±2.7)</td>
<td>37.5(±3.9)</td>
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<tr>
<td>Black</td>
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<td>Total</td>
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<td>11</td>
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<td>12</td>
<td>41.8(±5.6)</td>
<td>32.4(±3.8)</td>
<td>38.9(±2.8)</td>
<td>40.2(±2.7)</td>
</tr>
</tbody>
</table>

\(^\dagger\) Inadequate physical activity defined as less than 20 minutes of vigorous physical activity on three or more of the past seven days and less than 30 minutes of moderate physical activity on five or more of the past seven days\(^\dagger\).
Trends in alcohol use

YRBSS data shows that a significant percentage of high school students currently drink alcohol (defined as ≥1 drink within thirty days prior to taking the survey).\textsuperscript{1,3,4} In general, drinking is reportedly more common among white and Hispanic adolescents than among black respondents (Table 2). In 1999, 39.9% of black adolescents admitted to consuming at least 1 alcoholic beverage within the last month compared to 52.5% and 52.8% of Hispanic and white respondents respectively. While there has been a small but statistically significant decline in the reported incidence of drinking among Hispanic and white adolescents between 1999 and 2003, the percentage of adolescents who identify themselves as current drinkers remained statistically the same among black respondents. In 2003, 37.4% of black students admitted drinking at least one drink in the preceding month while 45.6% of Hispanic adolescents and 47.1% of white students admitted to drinking within the last month.

The predominant drinking pattern among adolescents participating in the YRBSS is noteworthy. With the exception of black respondents, the majority of white and Hispanic students who report recent drinking admit that their drinking pattern includes binge drinking (≥ 5 drinks during one occasion within the last month). Of the white and Hispanic students surveyed in 1999 who admitted drinking at least once during the last month, 68% of white students and 61% of Hispanic students admitted to binge drinking within the last month; while 40% of black students reported binge drinking. From 1999 to 2003, the incidence of binge drinking among students who drink remained statistically the same.
Table 2
Alcohol consumption: % Prevalence among adolescents, Grades 9 through 12 (CI), absent values = data unavailable

<table>
<thead>
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<td>CT</td>
<td>Nat’l</td>
<td>Nat’l</td>
<td>Nat’l</td>
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<td>≥1 drink/month</td>
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<tr>
<td>≥5 drinks/occasion</td>
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<tr>
<td>Hispanic</td>
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<td>Total</td>
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<td>31.5(±2.4)</td>
</tr>
<tr>
<td>Black</td>
<td>16.0(±5.1)</td>
<td>11.1(±2.2)</td>
<td>15.3(±2.6)</td>
<td></td>
</tr>
<tr>
<td>Grade 9</td>
<td>18.5(±3.0)</td>
<td>21.1(±2.2)</td>
<td>24.5(±2.8)</td>
<td>19.8(±2.4)</td>
</tr>
<tr>
<td>Grade 10</td>
<td>31.0(±8.0)</td>
<td>32.2(±3.1)</td>
<td>28.2(±2.6)</td>
<td>27.4(±2.9)</td>
</tr>
<tr>
<td>Grade 11</td>
<td>35.2(±5.9)</td>
<td>34.0(±2.9)</td>
<td>32.2(±3.4)</td>
<td>31.8(±3.0)</td>
</tr>
<tr>
<td>Grade 12</td>
<td>42.7(±6.1)</td>
<td>41.6(±5.4)</td>
<td>36.7(±3.7)</td>
<td>37.2(±2.3)</td>
</tr>
</tbody>
</table>


*Trends in Sexual Behavior: Lifetime sexual activity*

YRBSS data shows that nationally, the prevalence of sexual activity among high school aged adolescents has not changed significantly between 1999 and 2003 (Table 3). Overall, 46.7% (CI ±2.6) of students surveyed reported intercourse at least once in their lifetime. The prevalence of lifetime participation in intercourse remained unchanged from prior survey years: 49.9% (CI ±3.7) in 1999 and 45.6% (CI ±2.3) in 2001. When viewing prevalence of lifetime intercourse by race, there was no statistically significant change between the survey years 1999, 2001 and 2003.

Reported participation in intercourse differed by gender among Hispanic and black adolescents, but not white adolescents. In 2003, 73.8% (CI ±3.5) of males admitted to intercourse at least once compared to 60.9% (CI ±4.0) of females. Among Hispanics, 56.8% (CI ±4.3) of males admitted to intercourse at least once while only 46.4% (CI ±3.6) admitted to the same.

The percentage of students who reported intercourse at least once steadily increased with grade level during the sample years 1999, 2001 and 2003. The increase was comparable between samples. Among ninth graders, 38.6, 34.4 and 32.8% reported sexual intercourse during sample years 1999, 2001 and 2003 respectively (CI ±9.1, 3.6 and 3.8). By the twelfth grade, the prevalence of intercourse had increased to 64.9, 60.5 and 61.6% for sample years 1999, 2001 and 2003 (CI ±4.9, 4.0, 3.8 respectively).
Table 3
Sexual activity: % Prevalence among adolescents, Grades 9 through 12 (CI), absent values = data unavailable

<table>
<thead>
<tr>
<th></th>
<th>1997</th>
<th>1999</th>
<th>2001</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CT</td>
<td>Nat’l</td>
<td>Nat’l</td>
<td>Nat’l</td>
</tr>
<tr>
<td>≥ 1sexual encounter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>56.7(±15.0)</td>
<td>54.1(±4.8)</td>
<td>48.4(±4.5)</td>
<td>51.4(±3.2)</td>
</tr>
<tr>
<td>Male</td>
<td>62.9(±5.1)</td>
<td>53.0(±4.9)</td>
<td>56.8(±4.3)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>45.5(±6.2)</td>
<td>44.0(±5.0)</td>
<td>46.4(±3.6)</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>39.6(±6.1)</td>
<td>45.1(±3.9)</td>
<td>43.2(±2.5)</td>
<td>41.8(±2.7)</td>
</tr>
<tr>
<td>Male</td>
<td>40.5(±7.5)</td>
<td>45.4(±4.2)</td>
<td>45.1(±2.7)</td>
<td>40.5(±3.5)</td>
</tr>
<tr>
<td>Female</td>
<td>38.8(±6.1)</td>
<td>44.8(±4.4)</td>
<td>41.3(±3.2)</td>
<td>43.0(±3.2)</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
<td>71.2(±8.1)</td>
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<tr>
<td>Female</td>
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<td>53.4(±5.1)</td>
<td>60.9(±4.0)</td>
<td></td>
</tr>
<tr>
<td>Grade 9</td>
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<td>34.4(±3.6)</td>
<td>32.8(±3.8)</td>
</tr>
<tr>
<td>10</td>
<td>33.4(±7.1)</td>
<td>46.8(±5.6)</td>
<td>40.8(±3.0)</td>
<td>44.1(±2.8)</td>
</tr>
<tr>
<td>11</td>
<td>52.8(±7.2)</td>
<td>52.5(±3.8)</td>
<td>51.9(±2.9)</td>
<td>53.2(±4.3)</td>
</tr>
<tr>
<td>12</td>
<td>67.9(±6.7)</td>
<td>64.9(±4.9)</td>
<td>60.5(±4.0)</td>
<td>61.6(±3.8)</td>
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<tr>
<td>≥ 4 sexual partners</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19.2(±9.1)</td>
<td>16.6(±3.6)</td>
<td>14.9(±1.7)</td>
<td>15.7(±2.2)</td>
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<td>Male</td>
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<tr>
<td>Female</td>
<td>10.5(±3.4)</td>
<td>9.5(±2.0)</td>
<td>11.2(±2.2)</td>
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</tr>
<tr>
<td>White</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8.6(±1.9)</td>
<td>12.4(±2.1)</td>
<td>12.0(±1.4)</td>
<td>10.8(±1.5)</td>
</tr>
<tr>
<td>Male</td>
<td>8.8(±2.1)</td>
<td>12.1(±2.8)</td>
<td>12.8(±1.5)</td>
<td>11.5(±1.9)</td>
</tr>
<tr>
<td>Female</td>
<td>8.4(±2.8)</td>
<td>12.7(±2.3)</td>
<td>11.1(±1.8)</td>
<td>10.1(±1.7)</td>
</tr>
<tr>
<td>Black</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>34.4(±10.7)</td>
<td>26.6(±3.7)</td>
<td>28.8(±2.5)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>48.1(±12.7)</td>
<td>38.7(±5.7)</td>
<td>41.7(±3.5)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>21.3(±8.8)</td>
<td>15.6(±3.6)</td>
<td>16.3(±3.5)</td>
<td></td>
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<tr>
<td>Grade 9</td>
<td>7.3(±4.4)</td>
<td>11.8(±2.3)</td>
<td>9.6(±1.6)</td>
<td>10.4(±2.0)</td>
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<tr>
<td>10</td>
<td>7.3(±2.8)</td>
<td>15.6(±5.0)</td>
<td>12.6(±1.8)</td>
<td>12.6(±2.4)</td>
</tr>
<tr>
<td>11</td>
<td>13.6(±5.5)</td>
<td>17.3(±4.1)</td>
<td>15.2(±1.5)</td>
<td>16.0(±2.6)</td>
</tr>
<tr>
<td>12</td>
<td>20.1(±6.1)</td>
<td>20.6(±2.8)</td>
<td>21.6(±2.4)</td>
<td>17.9(±2.0)</td>
</tr>
</tbody>
</table>

Of the students who reported intercourse at least once, significant numbers admitted to having four or more sexual partners. The prevalence of adolescents who reported four or more lifetime partners has remained stable during the sample years 1999, 2001 and 2003. Significantly larger proportions of
Black and Hispanic males report multiple partners compared to females. Overall, 14.4% (CI ±1.6) of high school students admitted to four or more partners. This proportion is unchanged from sample years 1999 and 2001 wherein 16.2 and 14.2% of students surveyed admitted to multiple partners (CI ±2.6 and 1.2).

Among Hispanics, the prevalence of multiple partners is twice as large among males compared to females. During sample years 1999, 2001 and 2003, the prevalence of multiple partners among Hispanic males was 23.0, 20.6 and 20.5% respectively (CI ±5.1, 2.8 and 3.5). A smaller proportion of Hispanic females reported having multiple partners: 10.5, 9.5 and 11.2% during the same sample period (CI ±3.4, 2.0 and 2.2 respectively). A similar pattern is observed between black males and black females. Of the black males sampled in 1999, 2000 and 2003, 48.1, 38.7 and 41.7% reported multiple partners (CI ±12.7, 5.7 and 3.5). Among females, 21.3, 15.6 and 16.3% reported multiple partners during sample years 1999, 2001 and 2003 (CI ±8.8, 3.6 and 16.3).

There is a consistent increase in the prevalence of multiple partners with grade level. By the twelfth grade, the percentage of students who reported having more than four sexual partners was twice as large compared to ninth graders. This trend was consistent for the sample years 1999, 2001 and 2003. Among ninth graders, 11.8, 9.6 and 10.4% admitted to multiple partners during sample years 1999, 2001 and 2003 respectively (CI ±2.3, 1.6 and 2.0). By the twelfth grade, the percentage of students reporting multiple partners during the same sample period had increased to 20.6, 21.6 and 20.3% (CI ±2.8, 2.4 and 2.0 respectively).
Trends in sexual behavior: Prevalence of condom use during intercourse

YRBSS data for 2003 shows that among high school aged students who are sexually active, 63% (CI ±2.5) reported condom use during last sexual intercourse. Reported condom use for 2003 is slightly improved compared to responses in 2001 when 57.9% (CI ± 2.2) of students surveyed reported condom use with last intercourse. When interpreting the data set by race, this small improvement in condom use is not observed, most likely due to the smaller samples and resultant increase in the confidence intervals (Table 4).

Table 4
Condom use with last intercourse: % Prevalence among adolescents, Grades 9 through 12, (CI), absent values = data unavailable

<table>
<thead>
<tr>
<th></th>
<th>1997</th>
<th>1999</th>
<th>2001</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nat’l</td>
<td>Nat’l</td>
<td>Nat’l</td>
<td>Nat’l</td>
</tr>
<tr>
<td>Hispanic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>55.2(±6.8)</td>
<td>53.5(±5.1)</td>
<td>57.4(±5.3)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>66.1(±7.8)</td>
<td>59.1(±6.5)</td>
<td>62.5(±4.8)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>43.0(±8.0)</td>
<td>47.6(±5.7)</td>
<td>52.3(±8.3)</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>55.6(±6.0)</td>
<td>55.0(±5.1)</td>
<td>56.8(±3.0)</td>
<td>62.5(±3.1)</td>
</tr>
<tr>
<td>Male</td>
<td>62.8(±10.1)</td>
<td>63.0(±5.0)</td>
<td>63.8(±4.0)</td>
<td>69.0(±3.7)</td>
</tr>
<tr>
<td>Female</td>
<td>48.9(±5.5)</td>
<td>47.6(±6.5)</td>
<td>51.0(±4.3)</td>
<td>56.5(±3.7)</td>
</tr>
<tr>
<td>Black</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>70.0(±5.4)</td>
<td>67.1(±3.5)</td>
<td>72.8(±3.7)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>75.3(±5.0)</td>
<td>72.7(±4.6)</td>
<td>81.2(±3.8)</td>
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</tr>
<tr>
<td>Female</td>
<td>64.5(±7.3)</td>
<td>60.7(±5.0)</td>
<td>63.6(±5.2)</td>
<td></td>
</tr>
<tr>
<td>Grade 9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>53.5(±8.8)</td>
<td>62.6(±6.1)</td>
<td>60.1(±4.5)</td>
<td>69.0(±4.7)</td>
</tr>
<tr>
<td>11</td>
<td>54.4(±9.3)</td>
<td>59.2(±4.8)</td>
<td>58.9(±4.0)</td>
<td>60.8(±4.8)</td>
</tr>
<tr>
<td>12</td>
<td>54.7(±9.0)</td>
<td>47.9(±5.7)</td>
<td>49.3(±3.1)</td>
<td>48.5(±3.7)</td>
</tr>
</tbody>
</table>

Condom use among black adolescents was more prevalent than among Hispanic or white adolescents; and this trend was observed during sample years 1999, 2001 and 2003. Among black students 70.0, 67.1 and 72.8% reported condom use with last intercourse during survey years 1999, 2001 and 2003 respectively (CI ±5.4, 3.5 and 3.7). During the same interval, 55.2, 53.5 and 57.4% of Hispanic
students reported condom use during last intercourse (CI ±6.8, 5.1, 5.3). A statistically similar proportion of white students reported condom use compared to Hispanic students.

Condom use declined with increasing grade level during sample years 1999, 2001 and 2003. Over this period 66.6, 67.5 and 69.0% of ninth graders reported condom use at last intercourse (CI ±7.8, 3.3 and 6.4). By the twelfth grade, condom use was reported by 47.9, 49.3 and 48.54% of students (CI ±5.7, 3.1 and 3.7).

Overall, there is a statistically significant difference in the percentage of females that reported condom use at last intercourse compared to males. A smaller percentage of females reported condom use at last intercourse compared to males. This trend is observed in 1999, 2001 and 2003. Over this period, 68.8, 65.1 and 65.6% of males reported condom use at last intercourse (CI ±2.6, 2.7 and 4.3). During this period 57.4, 51.3 and 50.7% of females reported condom use (CI ±3.1, 3.4 and 5.8).
Implication of risk behaviors among high school adolescents

The previous section has reviewed prevalent health behaviors among adolescents with particular attention to behaviors among black and Hispanic adolescents who together are the largest population in this study. While understand which health behaviors are the most prevalent among adolescents is important, this information is less meaningful without an understanding of how these behaviors affect adolescents’ health outcomes in the immediate future as well as their health outcomes once they are adults. The following section is intended to review contemporary thought on the implications of common health behaviors on the well-being of adolescents.

Together with prevalence data, understanding the implications of adolescent behavior allows for better guided selection of targets for intervention. The most prevalent risk behaviors identified by review of YRBSS data will be review here; namely inadequate physical activity, overweight, alcohol use and risky sexual activity. The discussion of physical inactivity and overweight is rather straightforward and intuitive. There is a long history of research in this field and the relationship between physical inactivity, overweight and subsequent disease is clear.

More of a challenge is the discussion of adolescent alcohol use. While the health effects of long term alcohol use are well known, these long term effects, while important, are probably less important that more acute risks of adolescent alcohol drinking—namely increased risk of accidental injury, increased risk of concurrent risky behaviors including sexual behaviors and other drug use. What makes the acute effects of adolescent alcohol use difficult to discuss is that researchers have found it difficult to separate the effects of alcohol use on adolescent judgment from adolescents’ baseline propensity to be less risk averse which in fact may cause drinking in the first place. This dilemma is an important one because it raises the question of whether specific alcohol interventions will be
efficacious in reducing concurrent risky behavior or if a more comprehensive intervention addressing adolescents’ poor risk assessment skills would be more appropriate.

**Physical inactivity and overweight**

Part of the urgency to address adolescent overweight is borne out of the obvious associated morbidities. Overweight and physical inactivity are important markers of health because both are positively correlated with increased incidence of hypertension and Type 2 Diabetes mellitus.\(^4,12,13\) A recent study suggests that race can impact the association between overweight and the magnitude of hypertension in adolescents.\(^14\) In a sample of 38,184 children, Rosner et al determined that while overweight increases the relative risk for hypertension in adolescents regardless of race, black children are more likely to experience higher blood pressure excursions at lower BMIs compared to white children. The implication is that black adolescents with only modest overweight are at risk of significant elevations in blood pressure and the associated cardiovascular risk. This data is likely to shape interventions aimed at black youth, with modest overweight and obesity being treated as equally risky.

The cost of allowing adolescent overweight and inactivity to go unchecked underscores the need to address this issue early before adulthood. When attempting to assess the cost to society of adolescent overweight, four areas should be explored:

- Cost of inpatient and outpatient medical care during adolescence
- Cost of inpatient and outpatient care as an adult if overweight persists
- Cost of inpatient and outpatient care for overweight adults who were not overweight as adolescents
- Lost productivity secondary to overweight associated morbidity, discriminatory wage practices, etc
While there is cost analysis data regarding overweight and obesity in adults, there is a paucity of similar data examining the cost of overweight and obesity in childhood. A Medline search for keywords: adolescent, obesity, and cost analysis resulted in 35 hits, of which only four were relevant.\textsuperscript{15-18} Of the four, only two presented new data.\textsuperscript{17, 18} Guijung Wang and William Dietz present data on the inpatient medical cost of obesity of children aged six to seventeen years, using data from the National Center for Health Statistics (NCHS) database.\textsuperscript{17} Analyzing the frequency of selected discharge diagnoses in consecutive three year samples between 1979 and 1999, the authors were able to establish that the incidence of obesity and comorbid discharge diagnoses have steadily increased. During their survey period, the incidence of obesity as a discharge diagnosis more than doubled from 0.36\% (Standard error 0.03) in the 1979-1981 sample to 1.07\% (SE 0.08) in the 1997-1999 sample. During the same period, the diagnosis of diabetes diagnoses associated with the diagnosis of obesity increased from 1.43\% (SE 0.006) to 2.36\% (SE 0.12). The authors noted a similarly increasing incidence of sleep apnea and gall bladder disease diagnoses associated with obesity. Multiplying the number of days of inpatients hospital days by the average daily cost of hospital service in 2001 constant dollars, the authors demonstrate that the cost of managing childhood obesity has more than tripled from $35 million in 1979-1981 to $127 million in 1997-1999 (SE not stated).

Their study is limited primarily by their inclusion criteria. The coding of the NCHS database does not distinguish between Type 1 and Type 2 Diabetes. For the purpose of their study, the authors assumed that patients discharged with the diagnosis of diabetes and obesity were Type 2. This assumption will result in the inclusion of some Type 1 diabetics who coincidentally are also obese in their cost calculation. Furthermore, the diagnosis of sleep apnea included patients with shortness of breath, wheezing and other issues, that while respiratory, appear unrelated to apnea and are not necessarily related to obesity. Another important limitation is the absence of controls to compensate for changing physician awareness, over time, to adolescent obesity and the impact this may have on the sensitivity of physicians to detect and document obesity. Lastly, the paper addresses the inpatient
cost of obesity, but does not address the cost of overweight in the outpatient setting. While this study has its weaknesses, it is the only original work, by my search criteria, describing the cost of adolescent obesity. Clearly, more research is warranted.

Li Yan Wang et al, demonstrated the cost effectiveness of Planet Health, one of the few successful obesity interventions. Planet Health, is a two-year middle school obesity prevention program. During the study period between 1995 and 1997, the original investigators found that their program reduced the prevalence of obesity from 23.6% to 20.4% while the prevalence of obesity in their control rose from 21.5% to 23.7%. In other words, 11 out of 641 students in their study cohort reduced their BMI to below the threshold of obesity. Interestingly, the intervention reduced the prevalence of obesity only among girls and had no effect on boys.

Wang et al, using several probability models to predict the lifetime prevalence of obesity among the study and control cohort based upon their performance in the program, starting weight and age dependant weight gain curves, were able to compare the projected obesity related health care cost of the two cohorts. The authors predict that the intervention will result in a 1.9% reduction in the prevalence of obesity during the lifetime of the study cohort compared to the control, which corresponds to a prevention of 5.8 cases of obesity out of 310 and a saving of 4.1 quality adjusted life years. The authors calculate that for an investment of $28 per student for the two year intervention (or $17,948 for all 641 students) the public will experience a lifetime healthcare and lost productivity savings of $25,261 (net benefit $7,313). Healthcare and productivity savings were calculated using standard models for cost due to illness.

The stated limitations of this study are that the authors retrospectively estimated the cost of the intervention instead of prospectively recording costs. Second, the authors used modeled predictions of future prevalence of obesity as the study and control cohorts. Direct observation of obesity in the
cohorts as they age would be ideal and would be a meaningful follow-up study. Third, this study used an outdated definition of obesity. The authors defined adolescent obesity as BMI > 85th percentile and adult obesity as BMI > 25. According to the present definition, the authors’ cohort overstates the effectiveness of the intervention and therefore the cost benefit.

The importance of addressing adolescent overweight and obesity is important because in the adult years, obesity and related disease disproportionately increases healthcare costs compared to other behavior related illness.\(^{19}\) Whereas smoking related illness increases the inpatient and outpatient medical cost by 21 and 29\% respectively, obesity and comorbid illness increases care costs 36 and 77\% respectively.\(^{19}\)

Trends in adolescent physical inactivity and associated overweight justify the development and implementation of health interventions. The increasing prevalence of adolescent overweight, particularly among black and Hispanic youth, threaten to significantly increase adolescent morbidity and associated health care cost.\(^{12,13,17}\) Adolescent overweight is predictive of adult overweight.\(^{20,21}\) Current trends in adolescents predict an increased prevalence of adult overweight. Adult overweight has been shown to be associated with significant morbidity and health cost.\(^{19}\) Data exists that suggests that adolescent health interventions can reduce the prevalence of adolescent overweight and prevent, to a limited extent, the development of overweight in adulthood.\(^{18}\) Cost analysis shows that such reductions in overweight and associated morbidity confers a modest, but significant cost benefit to the health care system.\(^{18}\) The factor limiting the cost benefit of studied interventions is the magnitude of overweight reduction achieved through intervention. More work in necessary to develop more effective interventions to help control projected cost associated with current trends in overweight.
Alcohol consumption

Of the risk behaviors followed by the YRBSS, alcohol consumption is the most prevalent irrespective of race or gender. The prevalence of alcohol consumption combined with the strong association between adolescent alcohol use and increased morbidity, mortality and increased participation in risky behavior underscores the need to better understand adolescent drinking and develop successful interventions. Recently, there have been several studies which have documented a significant association between adolescent drinking and several undesirable acute outcomes including accidental injury, accidental death, violence, and increased participation in risky sexual behavior. In addition to the acute morbidity of adolescent drinking, long term or delayed morbidity, including the risk of future dependence and related illness secondary to chronic alcohol abuse, are important considerations.

Since 1980, the top three causes of death in the United States among people aged 15 to 24 has been unintentional injuries followed by homicide then suicide. Among these deaths, post mortem analysis has demonstrated the presence of alcohol in more than 80% of cases. Analysis of nonfatal injuries also shows a strong association with alcohol use. This data documents an association and suggests a causal relationship between alcohol and death by homicide and suicide. To date, research showing causation is not available. While studies that reach beyond association and prove causation are important, their absence should not forestall attempts at interrupting behavior patterns that, at least by association, expose adolescents to increased risk of harm.

Violent behavior is an important consideration among adolescents. Violent behavior is common among adolescents who drink. Among adolescents who drink regularly, forty-eight percent admitted that they engaged in fighting that caused physical harm. The risk of engaging in violence increases with the volume of alcohol consumed, the most significant increase in violence is observed after
The relationship between alcohol and violent behavior is important because compared to non-drinking adolescents, adolescents who drink are more likely to sustain injuries requiring medical attention. Of trauma visits to the ED, 29.5% of patients aged 12 to 17 have positive blood alcohol content (BAC) \( \geq 100\text{mg/dl} \). Alarmingly, the incidence of intoxication coincident with trauma increases to 47% in patients aged 18 to 20 and is a more common coincident finding than sobriety among 21 to 25 year olds, occurring in 64.1% of trauma patients. Not only is adolescent intoxication associated with an increased incidence of injury requiring medical attention, it also predicts an increased risk of injury to vital part of the body, most notably the head. Furthermore, compared to sober trauma cases, adolescents who are injured while intoxicated are more likely to die from their injuries.

Beyond the association between alcohol and increased risk of acute bodily injury, alcohol use among adolescents has also been shown to be associated with engagement in sexual behavior. Several studies have shown that onset of alcohol use early in adolescence is associated with a larger number of sexual partners. In their sample of 1034 adolescents who were surveyed in the seventh grade and again in the tenth grade, Stueve and O’Donnell found that adolescents who began drinking as seventh graders were 1.54 times more likely (CI 1.10 – 2.26) to have more than two sexual partners by the tenth grade compared to peers who had not commenced drinking in the seventh grade.

Consistent condom use in the context of multiple sexual partners is an important determinant of STD exposure risk. While alcohol use has been shown to increase the incidence of unplanned intercourse, studies have not been able to definitively prove that alcohol use decreases the consistency of condom use. Morrison et al performed a well designed diary study wherein 112 sexually active adolescents who were blinded to the goals of the study completed daily diaries wherein they recorded the incidence and time at which they had intercourse, drank alcohol. The diaries queried several other behaviors that were intended to distract participants from the aim of the
study. The odds ratio for condom use against antecedent alcohol consumption was negligible: 1.06 (CI 0.60 – 1.87). Adolescents who drank alcohol prior to intercourse were just as likely to use condoms as adolescent who had not. This observation was supported by Leigh’s meta-analysis of four adolescent studies that reported an odds ratio of 0.92 (CI 0.75 – 1.14) between condom use and alcohol consumption.

Because many adolescents who drink engage in binge drinking, several authors have studied the relationship between binge drinking and sexual behavior. It is not surprising that the correlation between lifetime exposure to alcohol and number of sexual partners held true for adolescents who participated in binge drinking. Castilla et al demonstrated that the likelihood of multiple sex partners among adolescents increased with the number of episodes of drunkenness. Of their 5253 participant sample, 75.2% admitted to drinking alcohol within the previous year. They found that adolescents who drank without getting drunk were 1.4 times more likely to have two or more sexual partners than adolescents who did not drink (CI 1.0 – 2.0). Among adolescents who drank to the point of drunkenness at least once a year, the odds ratio for having two or more partners was 2.4 (CI 1.7 – 3.3). Among adolescents who drank to the point of drunkenness at least once a month, the odds ratio for multiple sex partners was 3.4 (CI 2.3 – 5.3).

While the data regarding binge drinking indicates a correlation with multiple sex partners, there does not appear to be a correlation between binge drinking and failure to use condoms. The odds ratios for condom use after consuming alcohol compared to adolescents who did not use alcohol are non-significant: OR = 1.2 with alcohol consumption but without drunkenness (CI 0.8 – 1.7), OR = 1.0 among adolescents who report at least one episode of drunkenness per year (CI 0.7 – 1.6), OR = 1.2 among adolescents who admit to at least one episode of drunkenness per month (CI 0.7 – 2.1). One study suggests that a sexual encounter is less likely to occur after binge drinking than after moderate drinking.
Despite what may appear to be significant data refuting the idea that alcohol reduces the use of condoms during sexual encounters, there are recent studies which point to the contrary. The question is by no means resolved, especially given the popularly accepted idea that alcohol impairs judgment. Whether this logic holds true for condom use is still debated among researchers.

Insight into the seemingly contradictory studies may be found in work that explores the context around sexual encounters wherein condoms were used versus encounters wherein condoms were not used. Several authors have noted that many of the larger and well regarded studies that address the issue of condom use have not taken into consideration the effect that partner familiarity has on the decision to use condoms. When investigators incorporated questions seeking whether a partner was new versus established, authors found that the strongest predicting factor of failure to use condoms was involvement with a trusted partner.37,40,41 One survey which included 1,417 young adults between 18 and 25 years of age found that both condom use and alcohol consumption were more common with new partners than with established partners.40 This data supports the idea that while alcohol consumption may be associated with a higher likelihood of sexual engagement, there is no effect on the decision to use a condom. Instead, the most reliable predictor of condom use is familiarity with the partner. Adolescents tend to use condoms with less regularity among partners that they trust; coincidentally, adolescents tend to use alcohol less frequently with trusted partners. Morrison et al in her diary study of adolescents found an odds ratio of 3.84 between condom use and the partner being new versus established (CI 2.30 – 6.41). Comparatively, the odds ratio for condom use and the presence or absence of antecedent alcohol was 1.06 (CI 0.60 – 1.87).37

While researchers have been able to document the association between alcohol consumption and increased sexual activity, it has been difficult to show a causal relationship between the two. Data supporting a causal relationship between alcohol use and risky sexual behavior would underscore the
importance to reduce and prevent alcohol consumption among adolescents. Unfortunately, the majority of existing data was developed using methods that rely on participants’ self-reporting of their own behavior either using diaries or surveys. The variables considered by surveys are limited by the scope of the questions and diaries are limited by the instructions that guide participants’ entries. Rashad and Kaestner have suggested that there are a multitude of social variables, which may have causal implications that go unmeasured using these standard methods. While the relationship between alcohol and sexual behavior may be causal, the observed association may be symbolic of a pattern of behavior with an altogether separate cause. Authors have argued that adolescents are inherently less risk averse and therefore engage in collection of behaviors risky. According to this hypothesis, alcohol consumption is not a predisposing factor to other behaviors such as sexual engagement, but instead is a comorbidity of a risky lifestyle.

Novel research techniques that usurp the limitations of surveys and diaries are being developed. The key in establishing causation is to observe behavior when access to alcohol is mediated by a third party and is therefore out of the control of the subject. While it would be unethical to design a study that monitors sexual behavior among a cohort of adolescents that are given alcohol versus a cohort that is denied alcohol, Christopher Carpenter has looked at the impact of zero tolerance laws on sexual behavior among adolescents. Zero tolerance laws have been broadly adopted by all fifty states and have made illegal any noticeable amount of blood alcohol among drivers under the legal drinking age. In his study, Carpenter argues that zero tolerance laws act as a third party control on alcohol consumption among adolescents. In this scenario, Carpenter assumes that the implementation of zero tolerance laws creates a large disincentive toward underage drinking and thereby dramatically reduces alcohol consumption among this population. By comparing behavior before and after the implementation of these laws, more concrete statements can be made about the role of alcohol in sexual decision making.
Carpenter studied changes in gonorrhea rates among adolescents before and after the enforcement of zero tolerance laws as a proxy for sexual activity. Carpenter reports CDC data showing a significant drop in reported gonorrhea rates among 15 to 19 year olds before and after the implementation of zero tolerance laws between 1981 and 2000. Among non-Hispanic white adolescents, Carpenter notes that gonorrhea rates decreased 82% among males and 61% among females. Among black adolescents, Carpenter notes a decrease of 54% among males and 36% among females. When comparing the effect of zero tolerance laws against other alcohol laws that impact adolescent drinking, namely beer taxes and enforcement of the minimum legal drinking age, Carpenter found a statistically significant effect of zero tolerance laws on gonorrhea rates among white adolescent males (risk reduction of 0.109, SE 0.0142, significant at 5%). Among white adolescent females, Carpenter reports a gonorrhea risk reduction of 0.162 – 0.182 attributable to zero tolerance laws (SE 0.056 – 0.058, significant at 1%). Carpenter did not find a significant risk reduction among black males or females.

While Carpenter’s study is rare in that it seeks to observe sexual activity among adolescents when access to alcohol is limited by a third party, there are several weaknesses to the study. Carpenter uses proxies to measure the two behaviors that he is attempting to study: adolescent drinking and adolescent sexual activity. Carpenter uses zero tolerance laws as a proxy for reduced alcohol consumption among adolescents without any direct measure of alcohol consumption. While prior work by Carpenter demonstrated that the implementation of zero tolerance laws decreases the incidence of binge drinking among adolescents by about 13%, he finds that zero tolerance laws were associated with an equal increase in moderate drinking among the same population, presumably as binge drinkers reduced their intake in response to the new law. While Carpenter may be accurate in stating that zero tolerance laws reduce the total volume of alcohol consumed, there is no evidence to support the idea that reducing the volume of alcohol consumed reduces an adolescent likelihood of engaging in sexual behavior. To the contrary, work by Bisakha Sen provides data supporting the
concept that moderate drinking among adolescents is more conducive to sexual behavior compared to binge drinking, presumably because binge drinking has a higher likelihood of leaving the drinker incapacitated. Carpenter’s study is in a position to refute Sen’s data except that Carpenter does not directly measure sexual activity, instead he uses reported cases of gonorrhea as a proxy for sexual activity.

An aspect of the zero tolerance laws that Carpenter alludes to but does not explore in his study is the possibility that such laws may encourage drinking at home by placing a large disincentive on driving after drinking at a bar or club that is not walking distance from home. Drinking location is a worthy consideration, as Wells et al found that adolescents’ tendency toward aggressive behaviors depends in part on whether they are drinking at home or in a public environment. While Wells et al did not investigate the relationship between drinking context and sexual behavior, their demonstration of the effect of drinking context on behavior suggests a variable that Carpenter might have considered. Zero tolerance laws may have diverted adolescent drinkers into private homes and out of reach of the law. There may be a context dependant changes in behavior independent of alcohol consumption that are contributing to Carpenter’s measured outcome that he is not controlling for.

Lastly, Carpenter’s use of reported incidence of gonorrhea as a proxy for adolescent sexual activity is problematic for several reasons. First, as Carpenter admits, the nation had been observing a downward trend in gonorrhea rates during the 1980s and 1990s, the same time when zero tolerance laws were being introduced. While this downward trend may well have been the result of zero tolerance laws, there were several historic circumstances that could account for the decreased incidence of gonorrhea, most notably a heavy STD awareness campaign driven largely by an appropriate national concern regarding HIV. Additionally, inconsistent reporting of gonorrhea cases may also introduce a margin of error that Carpenter did not control for.
Understanding the impact of adolescent drinking on subsequent dependence is another area of interest to the research community. Several studies have documented an association between age at drinking onset, gender, binge drinking behavior and likelihood of subsequent dependence. While the association between these predictors and subsequent dependence is clear, a causal relationship has yet to be proven. While there may be a causal relationship between binge drinking or age at drinking onset and dependence, these predictors may instead be an expression of a psychosocial or genetic predisposition that is predictive of alcohol dependence. York et al performed a retrospective study of 2,276 adults aged 19 to 91 (mean 44.6 years) wherein respondents reported the age at which they first consumed alcohol (other than just a taste) and correlated that information with the reporters drinking behavior since initiation. While there was no correlation between age of drinking onset and current drinking behavior, York did demonstrate an association between age of onset and lifetime risk of dependent behavior. For every year of additional age before drinking onset, the lifetime risk of dependent behavior decreased by a factor of 0.88. York also showed that typically, men begin drinking earlier than women with the mean age of drinking onset being 15.73 years for men and 17.92 for women (SEM 0.12 and 0.13 respectively).

Bonomo et al performed a similar study with mixed prospective and retrospective elements in Australia of 1,943 adolescents. Bonomo et al surveyed a cohort of adolescents for a period of six years. During the sentinel survey, the investigators assessed respondents’ age at first exposure to alcohol, present drinking behavior and other drug and health behaviors. At six month intervals for the next three years, the investigators reassessed respondents’ behaviors. A final follow-up survey was performed three years after the last semi-annual survey. Whereas York et al associated early drinking onset and binge drinking with an increased lifetime risk of alcohol dependence, Bonomo et al show that in their sample, frequent binge drinking is associated with increased likelihood of dependent behavior as young adults in the final survey OR 6.7 (CI 3.6 – 12).
Sexual behavior

The prevalence of sexual activity among adolescents, and more importantly intercourse without condom use, has significant implications with regard to adolescent health. Existing data regarding adolescent pregnancy rates, STD prevalence and psychosocial issues regarding the sequellae of unprotected intercourse paint a mixed picture regarding the success of interventions aiming to improve adolescents’ decisions regarding sexual behavior. While the last ten years has seen a decrease in the teenage pregnancy rate, the last three years has seen an increase in the prevalence of syphilis and Chlamydia. Alarmingly, as adolescents get older they report less consistent condom use while at the same time they report a larger number of partners.

The inverse relationship between prevalence of sexual activity and the prevalence of condom use along with a similar relationship between number of sexual partners and condom use is alarming. The fact that the prevalence of condom use drops from nearly 70% among 9th graders to 50% among 12th graders underscores the need for booster interventions during the latter half of students’ high school careers to address sexual behavior. Timing booster interventions before condom use reaches its nadir is important as the rate of STD infection has been shown to be significantly high among individuals who use condoms inconsistently.48

The need for successful interventions for adolescents regarding sexual behavior is apparent when considering the age distribution of new STD infections. In 2004, the Chlamydia infection rate, as reported by the CDC, among females aged 15-19 was 2,761.5 per 100,000. This rate overshadowed every other age group regardless of gender. Among males, the age group with the highest Chlamydia infection rate was the group aged 20-24 years with an infection rate of 744.7. See chart. Prevention of Chlamydial infection, especially among adolescents, is an important step toward preventing Pelvic Inflammatory Disease and protecting a young woman’s reproductive potential. The association
between Chlamydial infection and HIV co-infection\textsuperscript{49} underscores the need to emphasize the need for condom use during intercourse.

The incidence of gonorrhea declined in 2004 following a twenty year national trend with a national infection rate of 113.5 per 100,000. This statistic, however, obscures the disproportionate incidence of gonorrhea in minority communities. In contrast to the overall national statistic, black females aged 15 to 19 years have the highest gonorrhea rate despite a 19.7\% decrease in new cases between 2000 and 2004. In 2004, the infection rate among black females aged 15 to 19 years was 2,790.5 per 100,000. Similar to infection patterns observed with Chlamydia, females (all races together) had the highest infection rates: 610.9 per 100,000 among 15 to 19 year olds. Among males aged 15 to 19 years, the infection rate in 2004 was 252.9 per 100,000.

While the teenage pregnancy rate has been declining over the last ten years, approximately 900,000 teens become pregnant in the United States each year.\textsuperscript{50} Teenage pregnancy is associated with a greater risk of medical and psychosocial complications compared to adult mothers.\textsuperscript{50-52} Infant and neonate death is two to three times more common among adolescent mothers compared to mothers aged 20 to 29 years.\textsuperscript{52} The incidence of maternal death is two fold greater among adolescent mothers compare to older mothers.\textsuperscript{50} Post partum depression is three times more likely among adolescent mothers compared to adult mothers.\textsuperscript{51}

The behavior patterns of adolescent sexual behavior coupled with the medical consequences of unwise decisions underscores the need to develop effective interventions that address adolescents’ sexual behavior and health. Decreasing condom use with age suggests that interventions should continue through high school with boosters in the Junior and Senior year when condom use reaches the lowest level observed during the high school years while the percentage of students with more than four lifetime partners is the highest.
Conclusions

I have reviewed trends in adolescent behavior as these statistics helped to shape the focus of the curriculum studied in this project. While there are several risky behaviors that adolescents engage in, it was my goal in reviewing behavior trends, to identify one or two that would become the focus of the curriculum. I felt that designing a health curriculum that was attempted to be entirely comprehensive would have been problematic. First, it would have been difficult to develop a curriculum that could have achieved so comprehensive a goal in the limited number of sessions that were available. Second, accurately assessing a curriculum with many more learning objectives would have proved a sizeable task. Lastly, behaviors that are less prevalent or have health outcomes that are difficult to measure are less than ideal targets for interventions as measuring efficacy is much more difficult in these circumstances.

Thus, the goal of this review was to identify behavior patterns that fulfill the following characteristics:

- Behaviors that are prevalent within the adolescent community
- Behaviors that have measurable health outcome
- Behaviors whose sequelae are significant and preventable
- Behaviors whose sequelae are easily measurable

According to these criteria the following behaviors were selected as potential targets for the curriculum:

- Inadequate physical activity
- Poor nutrition
- Alcohol use
- Condom use and sexual behavior
Review of YRBSS data shows that inadequate physical activity among adolescents is an endemic problem. Coupled with poor nutrition, these two problems have been shown to have a strong association with poor health outcomes, including increased risk of overweight, obesity, Diabetes mellitus and hypertension. Beyond traditionally described health outcomes, recent research has begun to uncover the negative psychosocial impact of overweight on self-esteem as well as negative impact on perceived self-efficacy. Reduced perceived self efficacy has been show to reduce the likelihood that attempts at behavior modification will be successful. Interventions targeting inadequate physical activity and poor nutrition offer several outcomes to measure efficacy. Beyond curriculum content mastery, several health outcomes can be monitored with relative ease; among them are: BMI, waist to hip ratio, incidence of hypertension, and Diabetes.

Alcohol use is another behavior that YRBSS data shows to be remarkably prevalent. Furthermore, both alcohol use and binge drinking appear to increase in prevalence when comparing prevalence among 9th graders to the prevalence among successive higher grades. While there is debate regarding the acute impact of adolescent alcohol use on health and other risky behaviors, there is sufficient evidence to defend the conclusion that adolescent alcohol use is associated with an increased in unplanned sexual encounter and number of total sexual partners. Furthermore, elevated blood alcohol levels are observed in the vast majority of adolescent trauma cases that present to the emergency department. While the effects of alcohol intervention are more difficult to assess than interventions targeted at physical inactivity, the implication that adolescent drinking has on adolescent health justifies its consideration as a target in health education curricula.

While the CDC has reported a general decrease in STD infection among adolescents, infection rates among black and Hispanic minorities have either decreased less dramatically, have remained flat, or in the case of syphilis, have increased in recent years. With the exception of viral pathogens, STDs are easily curable. This however does not make the issue of STDs benign or unimportant. Delayed
treatment of bacterial STDs creates the potential for irreparable damage to the female reproductive tract; and the behaviors that lead to bacterial STDs expose adolescents to risk of HIV infection.

In designing this curriculum, I have chosen as my focus physical inactivity and nutrition. They are both prevalent problems among adolescents and disproportionately affect black and Hispanic students who comprise the majority of my study cohort. The outcomes of poor nutrition and inadequate physical activity are the easiest to objectively measure compared to the outcomes of the other behaviors described above. Lastly, effective interventions regarding adolescent activity and nutrition are rare. The national health initiative that was generated by HIV has produced a larger number of interventions targeting sexual behavior than adolescent overweight/obesity has spawned regarding activity and nutrition. Among the interventions that targeted sexual behavior several have been shown to be effective and the nation has seen a dramatic reduction in new HIV infections. A similar decrease in the incidence of adolescent overweight, obesity and comorbid conditions has not been observed in response to existing exercise and nutrition interventions.

While nutrition and physical activity are the focus of this curriculum, it is not to the total exclusion of other health topics. Smoking behavior is addressed in the context of cardiovascular health. STDs are addressed in the context of a session dedicated to infectious diseases. Alcohol is addressed in the context of the gastrointestinal system.
HYPOTHESIS

The primary objective of this study is to determine the efficacy of an anatomy based health education curriculum taught by medical students in improving health knowledge among high school aged adolescents. My hypothesis is that this curriculum will increase students’ post exposure fund of health knowledge compared to their pre exposure fund of knowledge and that this knowledge benefit will exceed the knowledge benefit attributable to life experience during the study period.

A separate corollary study not described here seeks to explore whether knowledge gained through exposure to this curriculum translates into changes in attitudes toward health behavior as well as changes is reported incidence of risk behaviors.
METHODS

Overview

The methodological approach to this project involved several steps outlined below:

- Curriculum design
- Curriculum content
- Development of assessment tools
- Selection of control and study cohort
- Informed assent from students and informed consent from parents
- Psychosocial safeguards for students exposed to the anatomy lab
- Curriculum implementation and assessment
- Data analysis

Each of these steps will be described in detail under its own heading. The following is a broad overview of the study methods.

This study involved 40 Juniors from the health science track who were exposed to the study curriculum (study cohort). Each student acted as his/her own control by using pre and post test assessment protocols. An additional cohort of 31 Juniors from the business track who did not receive formal health education training served as a secondary control. The cohort exposed to the study curriculum took the General Health Knowledge Assessment (GHKA) in September before the curriculum began and again in May when the curriculum was complete. The GHKA is a multiple choice on-line exam, that I developed exclusively for this project, containing 42 items covering health content that administrators at Career high school agreed students should be proficient with upon completing a high school. In addition to the GHKA, students exposed to the study curriculum took
smaller pre and post tests before and after each curriculum unit. The unit pre and post test consisted of ten to fifteen multiple choice items that were completed online in the computer lab at Career High School. The interval between the pre test and the post test was one month.

The control cohort was not exposed to the study curriculum. Career High School does not have a formalized health education curriculum and thus the control cohort essentially is a placebo group, with students spending their class time in a business management course. Given our limited access to these students, this cohort of students took the GHKA, in paper format, once at the end of their health education course in May. This allows us the compare the level of content mastery at the endpoint of the study curriculum with the level of health knowledge that is acquired through life experience. While I would have liked to assess this group more extensively, the need to work within the parameters allowed by the high school administrators required me to make compromises. With few options available to assess this group, the data point that was obviously most important was the level of mastery achieved at the end of the control curriculum.

The study curriculum is composed of 11 semi-weekly visits to the Yale anatomy lab guided by first year medical students and four sessions led by a medical student at Career High School. The first session served as an orientation session for the students. Students listened to an informal introduction by Dr. William Stewart, Section Chief of Anatomy wherein he addressed common questions and fears that students have before entering the lab. Among these questions, Dr. Stewart explained how the body donation program procures cadavers for use in the lab; he explained how the bodies are prepared for use in the lab; he explained the safety measures that are taken to prevent transmission of pathogens. Finally, Dr. Stewart acknowledged that some students may feel uneasy about being in the lab before, during or after the experience. He reiterated the point that the sessions are completely voluntary and that any student could opt out of any or all sessions at any time. Dr. Stewart informed students of the alternative activities that were available for students to participate in if they left during
a lab session. By offering alternative activities we were attempting to remove any social obstacles that would otherwise have prevented a student who was uncomfortable with the lab from leaving the lab. Alternative activities included both academic and non-academic options. For students who needed support, a medical student, the Career High School teacher and Dr. Stewart were available to offer support. For students who opted out for other reasons but wanted to engage in an alternative academic experience, they could learn most of the curriculum objective by reviewing x-rays with a medical student.

After the orientation session, students returned to the lab every other week on a Wednesday or Thursday for their learning experience. The forty students who were exposed to the study curriculum were divided into two twenty student cohorts. Half of the students visited the lab on alternating Wednesdays and the other half on alternating Thursdays. During each visit, the students were divided into groups of five or six students and they completed the lab objectives with a first year medical student. Each session targeted a single organ system, the health behaviors that can affect it and common diseases that can be exacerbated or caused by certain behaviors. Before each session, the students received a worksheet that they had to complete before the lab experience. The worksheet was designed to introduce the students to vocabulary they would encounter during the session. The worksheets also challenged students to formulate hypotheses about how certain behaviors would modulate the function of the organ system in question and how such modulation would affect the body as a whole.

The study curriculum consisted of five units. Each unit required two lab sessions to teach. An online multiple choice pretest was proctored at Career High School before each unit and a post test was proctored a month later after the unit was complete. Below are the titles of the five units

- Surface anatomy and the physical exam
- Cardiovascular disease and the cardiovascular exam
- Energy management
- Infectious disease
- Diagnostic testing

In addition to the 11 sessions that occurred in the Yale anatomy lab, students participated in 2 class projects designed to introduce them to the practice of healthy behavior. These projects were introduced to the students during four sessions that occurred at Career High School under the leadership of a medical student. The first project was a diet diary with calculation of daily caloric intake. The objective was to help students achieve a practical and usable definition for “a balanced diet” as well as teach students how to use the Nutrition Information panels on food items to make healthy food choices. Two in-class sessions were devoted to this activity and the students were given a diary that they completed during the winter holiday.

The second project was a diary of caloric expenditure. This activity was designed to compliment the first activity. Two sessions were devoted to this project. The object of this session was to demonstrate that physical activity is as important as a healthy diet. Students were given pedometers that they wore for a week along with an algorithm to estimate their caloric expenditure based on their height, weight and level of activity as measured by the pedometer. Students compared their caloric expenditure with their caloric intake estimated during the first project.

In the time period that the study cohort was being exposed to the study curriculum, the control cohort was participating in an unrelated business management course. While it is difficult to entirely control for contamination between the cohorts if both cohorts are in the same school, there was no overlap in schedules between the two cohorts so as to minimize the potential for contamination.
The control curriculum in this study is defined as the existing health education curriculum in use at Career High School. (adfad what is the duration of the curriculum, how frequently do students meet for lessons, how is their performance evaluated, during which year do the students take this course).

**Curriculum design**

*Overview*

The study curriculum was designed to accomplish two main objectives: 1) to impart basic health knowledge that satisfied the requirements of the school 2) to improve students’ attitude toward health behaviors while dissuading students from unhealthy behaviors. The research aim was to determine whether such an approach toward health education is an effective method of delivering health knowledge.

The curriculum was composed of five units whose titles were listed in the overview. Each unit required two sessions to complete for a total of 10 sessions in the Yale anatomy lab plus one orientation session. In addition, there were four sessions performed at Career High School for the purpose of completing 2 health related class projects. For each unit, the following materials were prepared:

- Detailed lesson plans for the med student teachers which were made available to the teachers via the internet on the course website one week prior to the beginning of a new unit. Lesson plans are reprinted in Appendix B.
- Worksheets for the high school students designed to introduce them to unit vocabulary and the teaching objectives. These materials were distributed in paper format the week prior to the beginning of the unit. These materials are reprinted in Appendix D.
• Electronic pre and post tests containing between ten and fifteen multiple choice items which students took via the internet from Career High School before and after each unit. These assessments are reprinted in Appendix C.

• Worksheets and handouts for the two class projects. These material are reprinted in Appendix D.

The design of this curriculum incorporates several elements which make the study curriculum different from the traditional health educational curricula. The study curriculum was designed to deliver content using the following structural elements:

• Hands on exploration in an anatomy lab
• Small group learning emphasizing social support
• Modeling of healthy behaviors and social skills through interaction with first year medical students
• Emphasis on creating an environment that normalizes healthy behavior
• Activities that encouraged students to plan healthy behaviors into their daily lives
• Medical student and teacher participation in planning activities

The curriculum was designed over a six month period employing a contemporary pedagogical approach. The primary teaching model incorporated into the curriculum was the exploration model. Care was taken to incorporate other teaching models in consideration of the concept of multiple intelligences. The curriculum encouraged peer education in the setting of the small group. The direct teaching model was used sparingly, usually in association with vocabulary and concept definitions. Assessment accommodations for multiple intelligences included: small group learning; multiple formats for students to demonstrate their proficiency including on-line examination, paper examination, small group participation, portfolio style projects. For study purposes, performance on
traditional multiple choice examinations was used as a measure of content mastery because of its objectivity, ease of scoring and resultant numerical score. The grade for the course was determined by the Career High School teacher independently from scores generated for the study. The Career High School grade was generated by considering performance on all of the assessment accommodations listed above. While each type of evaluative tool was given a numerical weight in the resultant grade, there nonetheless a significant amount of subjectivity associated with certain evaluative tools which made their inclusion in the study problematic. For example, generating a rubric for evaluating the quantity and quality of individual student participation in a way that is accurate, practical and avoids subjective bias is difficult.

Standard protocols for peer review were used to ensure the integrity of the curriculum regarding both pedagogical approach and content. The curriculum was reviewed in stages throughout its development by medical and high school faculty. The reviewers were Dr. William Stewart, Professor of Anatomy, Yale School of Medicine; Rose Coggins, Principal, Career High School; Dr. Abbie Benitez, Chair, Department of Science Education, Career High School; Shirley Neighbors, Teacher of Anatomy and Physiology, Career High School.

_Pedagogical approach_

_Motivation_

Teaching is the art of delivering content to students. Anyone who has either tried to teach or has been a student understands that the teacher’s command of content is necessary but not sufficient for the transfer of content from the teacher’s mind to the student’s. The example that comes to my mind is sitting through an Organic Chemistry small group section led by a brilliant teaching assistant who clearly knew the material, but struggled to impart that knowledge effectively to students. I remember
feeling a growing sense of frustration at the TA’s poor communication skills which made understanding the material nearly impossible. Frustration was compounded by the realization that, for most students in the class, the only reason to suffer through the session was to meet the requirement for medical school, not because of any interest in the subject matter. Combine that with the fact that the sun was shining brightly, students outside were enjoying an otherwise beautiful day, and all interest in paying any attention to what the TA was lost. I spent the rest of period counting the minutes until the end of the session and doodling in my notebook.

What I describe above is a constellation of factors that summed together resulted in an overwhelming lack of motivation. The teacher’s inability to effectively communicate coupled with student discomfort with the classroom environment relative to what was going on outside resulted in frustration which is the antithesis of motivation. The only remaining motivation to pay attention—doing well on the MCAT so as to be an attractive candidate for medical school—was so far off in the future as to have little impact on interest in a fifty minute class. This anecdote demonstrates what pedagogical theorists have spent years establishing through behavioral science: that learning cannot occur unless a student is adequately motivated to assimilate information. More importantly, theory suggests that several factors influence motivation including teacher communication, content relevance, culture, environment and so on.

Thus, when designing a curriculum, these aforementioned factors must be addressed if attempts to stimulate and sustain student motivation during each teaching encounter are to be successful. While it is agreed that motivation is an essential part of teaching, it is regarded as the most difficult part of a lesson to prepare for. Whereas many projects that aim to design a curriculum begin with content that investigators want to deliver and struggle to find techniques to motivate students to assimilate the content, this project began with the accidental discovery of a strong motivational tool and all that had
to be done was build content around it. The motivation that this curriculum capitalizes on is students’ intrinsic curiosity about their own bodies.

Modern motivation theory as it has been applied to education was first described by deCharms and reviewed by Cohen and suggests that motivation exists in two forms: intrinsic and extrinsic. According to deCharms, people who perform behaviors, such as learning, as the result of extrinsic motivation do so either to obtain an external reward or to avoid a form of punishment. Individuals who perform behaviors through intrinsic motivation, do so because their behavior has some internal meaning or relevance that is independent of external reward or threat of sanction. Cohen reviews studies showing that students who work from internal motivation achieve greater academic success than students whose motivation is external. Unfortunately, much of our educational system today is built upon extrinsic motivation.

Financial gain is frequently touted by parents and society at large as a motivation to complete high school and continue onto college. To an adolescent, whose working future seems too far away to be important, financial incentive is often ineffective and yields inconsistent results. While recent studies have used novel techniques to provide immediate financial incentives to students for good performance (eg providing a dollar each week to students with perfect attendance that then must be invested in the stock market) traditional critics have noted that gains in motivation usually disappear once the extrinsic incentive has been taken away. The consequence of poor grades is often a more temporally tangible and thus common extrinsic motivator. While evidence shows that extrinsic motivation becomes more common as students get older, it is less effective than intrinsic motivators in contributing to academic success.
Modern research in curriculum design has focused on identifying factors that enhance students’ intrinsic motivation to learn.\textsuperscript{54, 56, 57} From this work, several elements that contribute to intrinsic motivation have been identified:

- Culturally appropriate communication style
- Content delivery that provides context and explains the relevance of the material to students’ lives
- Affording students choice in how and what they learn as a means of allowing them to explore areas that are of particular meaning to them and to allow the teacher to learn what is most relevant to his/her students

The intrinsic motivation that Career High School students displayed during an informal visit to the anatomy lab that I happened to witness gave rise to this project. The students’ motivation can be understood in terms of the elements of intrinsic motivation described above. The role of medical student as teacher in the anatomy lab provided a culturally sensitive teaching environment. By culture, I am referring to the culture of youth. It was clear from the informality of the session and the sociable interaction between the high school students and the medical students that the high school students viewed their medical student teachers more as peers than they did their traditional teachers. Empirically, this was an asset to the learning experience and the students appeared more receptive to the information that was being presented to them by the teachers own account compared to their interest level in the classroom.

During the informal visit, the relevance of the information that was being presented was obvious from the questions that the students were asking. The medical students’ review of human anatomy sparked a plethora of questions many of which were obviously motivated by personal interest. On several occasions throughout the visit, I observed students ask insightful questions about a particular organ then justify their question by adding that a family member suffers from a disease affecting that organ. It is rare to see such pure intrinsic motivation, but once is it found it sustains the discussion, often
beyond the allotted time allowed for teaching. It was clear that this format of presenting material had relevance and meaning to the students and served to draw them into the lesson, leading to the types of questions that create understanding.

The third element of intrinsic motivation—choice—was also present in the interaction I witnessed in the anatomy lab. The question and answer format of the session allowed the high school students to guide the session in a direction that had meaning for them. Students questions probed knowledge that was relevant to their experience, eg., asking about the heart to better understand a relative’s heart attack. Within the bounds of human anatomy, the students had the freedom to direct their learning.

Thus, in the informal session that I had witness, several theoretical concepts crystallized to create the ideal learning environment. Students’ intrinsic motivation was stimulated by culturally appropriate delivery of content from teachers that the students were comfortable interacting with. Their motivation was further stimulated by the freedom to determine the course of their learning using a question and answer format and the availability of relevant information presented in a way that was meaningful to their existence. My goal in developing a curriculum based on the interaction I witnessed was to understand this motivational process and incorporate it into each encounter, thereby creating a climate wherein content could be delivered more effectively than in the traditional classroom environment.

To achieve intrinsic motivation within this curriculum, the basic format of the interaction that I observed was maintained. Medical students, as informal peer instructors, were the designated teachers of the course. The exploration model of teaching was the primary mode of content delivery so as to protect the question and answer format that allowed students to drive the session. In this model, the teacher stimulates a student driven exploratory process by presenting students with a challenge. Students collectively generate their own answers and test them against evidence. In our
case, the challenge is to explain the anatomical and behavioral origin of disease. The evidence is the cadaver. The relevance of the content was maintained by always relating the material to students’ lives. The curriculum focused on common themes in human wellness, disease and behavior. Students often shared how the topics presented were relevant to them or their families and were given the opportunity to guide the sessions within the boundaries of the teaching objectives in order to satisfy their own curiosity.

**Curriculum Content**

*Stimulating motivation by selecting relevant content*

In selecting content, two considerations were made: 1) content should maintain motivation 2) content should address common health problems to which behavior is a proven mediator. Based on these considerations, the following topics for inclusion in the curriculum:

- Surface anatomy and the physical exam
- Cardiovascular disease and the cardiovascular exam
- Energy management
- Infectious disease
- Diagnostic testing

From the discussion of motivation in the previous section, one of the key elements in maintaining motivation is ensuring that the content delivered is relevant to the student. For this reason, demystifying the doctor-patient encounter became a central theme. Interaction with the health care community is nearly a universal experience. The relevance of this theme is evidenced by frequent questions by high school students seeking to understand why physicians ask the questions that they do and perform the exam maneuvers that they do. These questions are understandable as the medical
culture is quite foreign to most patients. The medical history and physical exam frequently challenges typical boundaries of privacy and in this regard can be quite anxiety provoking. Minorities, who for several reasons have diminished access to care, face additional obstacle if they experience a low comfort level with care providers. Thus, for each unit, part of the lesson is dedicated to discussing the physical exam relevant to the part of the body being discussed. The relevance of this exercise is found in the ubiquitous experience of having visited a doctor and the knowledge that we will all continue to interact with the medical world in some way for the remainder of our lives. The goal is to familiarize students with the culture of medicine so as to make visiting a physician a less traumatizing experience. The need to bridge the cultural gap between medical practitioners and patients is underscored by research that suggests that patient perception of quality of care is related to their perception of gaps in the practitioners cultural awareness and sensitivity.62, 63

When asked by a show of hands, most students know someone who has had some form of diagnostic testing be it an x-ray, a stress test, a CT scan and so on. For this reason, a unit dedicated to diagnostic testing was developed to give students an opportunity to ask questions and learn about the different modalities that physicians use to gather information. This unit was intentionally left for last because it allowed for a broad review of the diseases that were covered earlier in the curriculum. The diagnostic tests reviewed were selected so as to correlate with diseases encountered in the course. As a fun exercise for the students, a radiology workshop was designed where students could attempt to correlate the anatomy they learned in the lab with their radiographic appearance on film. Once students obtained their bearing, they were challenged to identify anatomic abnormalities and hypothesize what type of disease process could give rise to the observed radiographic findings.

Selecting Content that Addresses modifiable disease risk factors

Beyond motivation, content was selected to address prevalent health problems that are mediated by behavior. National mortality data coupled with local behavior trends discussed in the introduction
indicate that cardiovascular disease is a remarkably prevalent health issue that is modified to a large extent by behavior. Furthermore, the behaviors that predispose a person to increased risk of cardiovascular disease have a cumulative effect which underscored the need for successful intervention during adolescence or earlier. Thus, a significant part of this curriculum is dedicated to addressing cardiovascular disease. The energy management unit was an extension of the cardiovascular unit. It goal was to address the relationship between nutrition, exercise and cardiovascular health. The significant prevalence of sexual activity among adolescents as evidenced by YRBSS data prompted the inclusion of sexual behavior in the curriculum. Given data supporting message-fatigue regarding safer-sex campaigns, I decided to take an altogether different approach toward sexual behavior, making use of the anatomy lab as a teaching tool. The approach to sexual behavior was through an understanding of the reproductive system, the diseases that affect it and the behaviors that predispose the reproductive system to disease.

Sexual activity is a prevalent behavior among adolescents. The prevalence of sexually transmitted infections, particularly Chlamydia and gonorrhea is highest among adolescents. Within the adolescent population, infection is more common among minorities and females. For this reason, a unit on infectious disease was included in this curriculum. This unit was designed to cover a broad range of pathogens including enteric organisms implicated in food contamination, tuberculosis and sexually transmitted diseases. The rationale for including several seemingly unrelated pathogens was an attempt to avoid the stigma that often surrounds sexually transmitted infections. The hope was to present STIs, for what they are: pathogens whose transmission, like many others, is mediated by behavior.
Specific learning objectives for each unit

The lesson plans for each unit can be found in Appendix B and provide a comprehensive description of the learning objectives for each unit. The pre-lesson worksheets that were distributed to the students prior to their visits to the lab show how the objectives outlined in the lesson plans were translated and presented to the students. These worksheets can be found in Appendix D.

Development of Assessment Tools

Overview

An appropriate assessment protocol along with appropriate assessment tools is necessary when deploying a curriculum. Contemporary pedagogical theory suggests that the ideal assessment strategy accomplishes several goals:

- Enhances learning
- Accommodates multiple intelligences
- Accurately and reliably determines whether curriculum objectives have been met.

Specific to this project, the assessment protocol and tools should also provide an accurate means to make a quantitative comparison between the study and control experience.

Unfortunately, it is nearly impossible with a single tool to achieve the assessment objectives outlined above. Each assessment tool has its advantages and disadvantage and therefore satisfies each of the above objectives with to a different degree. Thus, similar to most well designed curricula, this curriculum utilizes several assessment types in order to assess student competency, enhance learning and accommodate multiple intelligences. This curriculum makes use of the following assessment tools:

- Computer enhanced multiple choice exams
- Pre and Post testing
• Evaluation of small group participation
• Portfolio style projects

These varied assessment tools allow multiple opportunities for students to demonstrate their knowledge in keeping with the theory of multiple intelligences (reviewed in detail below). The inclusion of projects provides students some degree of control and freedom in their learning and assessment. The projects in this curriculum presented students with a problem as well as the resources and tools to solve it. The successful completion of the project entailed learning how to use the tools provided then applying them to complete the assigned task. Students were assessed on their ability to apply these learned skills to the assigned problem. In this way, projects served as both a teaching and evaluative tool. The inclusion of computer enhanced multiple choice exams provides a standardized method of quantitatively measuring student performance while addressing some of the limitations of traditional multiple choice exams.

The Theory of Multiple Intelligences

The theory of multiple intelligences was first introduced by Gardner in 1983\textsuperscript{65} and is reviewed by Diaz-LeFebvre.\textsuperscript{64} The theory suggests that knowledge can be expressed in a multitude of ways using a variety of media (eg written, oral, demonstrative, artistic). In this model, intelligence is defined as the ability to express knowledge through a particular medium. The term multiple intelligences reflects the understanding that there are multiple means of expressing knowledge and therefore there are many types of intelligence. The preferred medium through which an individual expresses knowledge is highly dependant upon cultural and social experience. The theory postulates that as educators, we may overlook the intelligence of students, particularly those whose experience is different from ours, if we do not provide opportunities for students to demonstrate their knowledge in a way that accommodates their learning style and mode of intelligence. This theory has been applied to reach students who were traditionally labeled as difficult, uncooperative or disruptive. Viewed
through the lens of multiple intelligences, the difficult or uncooperative student may be displaying
this behavior because he or she is frustrated by not being provided a medium through which to
acquire new information nor demonstrate proficiency. Isolated in this way, a student becomes
frustrated and often disruptive.

With this in mind, both teaching and assessment should reflect and accommodate multiple
intelligences. The appreciation of multiple intelligences necessitates the use of several types of
assessments so as to provide more than one way to demonstrate knowledge. In developing
assessments for this curriculum, several assessment types were used. This provided students multiple
opportunities to demonstrate their knowledge through different media. While it would be ideal for
performance on all assessments to be used to evaluate ability of this curriculum to improve health
knowledge, the difficulty in standardizing the grading of non-traditional assessments makes their
inclusion difficult. For the purposes of this study, results from multiple choice exams are used to
assess the study curriculum. The additional assessments including assigned projects were used as a
teaching tool and as a means for Mrs. Neighbors to generate student grades for their participation in
the course which was entirely separate from this study.

*Multiple Choice Exams: Pros and Cons*

Among the limitations of the traditional multiple choice exam is that it is teacher centered rather than
student centered. Information flows in one direction from the student to the teacher and there is a
limited role for teaching. It is not surprising that the traditional exam is unidirectional as it was
designed to provide a convenient and easy method for teachers to evaluate students. One could argue
that traditional exams do facilitate learning when a student reviews his/her exam after it has been
graded. While theoretically this may be true, in practice it is not. When students do poorly on an
exam, frequently their frustration with their performance limits their interest in diligently reviewing
the exam to learn from mistakes. This effect is often magnified by the temporal separation between
when the test was taken and when the exam is available for review. The longer a student waits to receive feedback on their exam, the less relevant it becomes to their current performance. For those students who perform very well on an exam, there is little incentive to review their answers. For multiple choice exams, reviewing correct answers is a futile exercise as student cannot ascertain from the answer key whether their correct response was the result of correct application of a learned concept versus guessing versus serendipitous application of a flawed concept.

Despite the limitations of traditional multiple choice exams, they are still widely popular for pedagogically weak yet practical reasons. First they are remarkably easy to administer compared to other assessments. Second, they are even easier to score especially with the use of answer grids and an automated scoring device. Third, multiple choice exams generate objective, numerical scores which can be directly compared to other scores. For these reasons, multiple choice exams are unlikely to fall into complete disfavor. However, this does not mean that they cannot be improved.

In this study computer enhanced multiple choice exams were used to take advantage of the benefits of multiple choice exams while providing opportunities for students to learn more readily from the exams. With a few exceptions students took computer based exams. Questions were presented using Blackboard™ (a web based learning package). Screen shots can be found in Appendix A and C. Students marked their answer choices by clicking the radio button next to the desired answer choice. Blackboard encourages learning through test-taking by providing instant feedback that is tailored to the student’s response once the exam has been completed. This feature overcomes the typical apathy that students often have toward reviewing their errors particularly when this opportunity is chronologically much later than the exam date. By engaging the students in exam review, Blackboard creates a bidirectional exchange of knowledge. The feedback offered to students reviews the concept central to the question asked and is more valuable than simply revealing the correct answer as is typical with traditional exams.
Project Based Learning and Evaluation

Project based learning was incorporated into the curriculum out of appreciation for the various learning styles commonly found among students. Evidence has shown that curricula that employ a diversity of teaching and assessment techniques are more successful than curricula that rely on one teaching strategy. For this reason, the study curriculum was designed to incorporate several teaching and learning styles. This diversity of teaching and assessment would provide the highest likelihood of measuring a positive effect on health knowledge.

The curriculum was designed to include two projects, one for each semester that addressed the relationship between nutrition, exercise and cardiovascular health—one of the core elements of the curriculum.

The collective goals of the two projects were:

- Establish the relationship between healthy eating habits, healthy exercise habits, cardiovascular health and sense of well-being
- Increase students’ consciousness to the nutritional value of the food they consume
- Develop student skills at using Nutrition Facts panel to estimate their caloric intake
- Increase students’ consciousness to their level of physical activity
- Develop student skills at estimating daily caloric expenditure
- Encourage healthy food choices along with physical activity
Project 1: Assessment of daily caloric intake

Two classroom sessions, each ninety minutes long, were dedicated to this project. The first session occurred three days before the students left for winter break. The project task (calculating daily caloric intake over a five day period) was to be completed over the break. The second session, designed as a debriefing, occurred a week after the students returned from break and provided an opportunity for the class to compile a database of their results, analyze the data for trends and reflect on elements of the exercise that were difficult, eye-opening, rewarding or otherwise of psychosocial significance to the students.

The objectives for the first session were:

- Introduction of the project’s overall purpose
- Development of student motivation
- Concept development
  - Relationships between nutrition, physical activity and cardiovascular health
  - Understanding what information is available on Nutrition Facts labels
  - Gathering and using Nutrition Facts information to estimate calories consumed
  - How to maintain a diet diary
  - How to estimate portion size
- Diet diary demonstration: What did the teacher have for lunch?
- Students exercises:
  - Calculate the caloric content of the teacher’s lunch
  - Was the teacher’s lunch healthy based upon fat, carb, protein and total calorie content?
  - Calculate the caloric content of your lunch today
- Review of instructions for maintaining a five day winter break diet diary and calculating daily calorie consumption
Upon returning from winter break, the students’ diaries and calculation worksheets were collected and graded. The grades generated were not used for study purposes but were used by Mrs. Neighbors to generate a grade for the course. Students were graded for their completion of the following tasks:

- Thorough and complete record of meals
- Plausible notation of servings consumed
- Accuracy of calculations
- Data presentation

After the students’ work was reviewed and graded, a histogram was generated demonstrating the distribution of caloric intake among the students over the five day exercise. Both Mrs. Neighbors and I participated in completion of diaries and our data was included in the histogram. The data was presented the data to the students during a debriefing session and my own diet diary was used as an example for class discussion.

The class was encouraged to review my diary and critically evaluate it for patterns of eating behavior, nutritional integrity etc. This exercise was intentionally assigned during a holiday with the expectation that eating habits would be poor. This made the discussion of eating habits easier because everyone had a plausible excuse for eating habits that they may feel uncomfortable with. The classroom discussion focused on how easy it is to load up on calorie dense foods. Students shared their own experiences while maintaining a diary. Students were asked them to compare their perception of their diet before they completed the diary to their perception after they completed the diary and had, in their possession, objective data about their nutritional habits. They were asked students to comment on what they found easy and what they found difficult about completing the project.
After reviewing the histogram, polling students’ perception regarding their diet and discussing challenges posed by the project the class proposed practical behavior modifications that could be easily adopted to improve diet. I returned to my diet diary as an example. The students were asked to identify “trouble spots” in the teacher’s diet diary, my diary and their own. The class was asked to generate suggestions about how the teacher and I could avoid the nutritional pitfalls that they identified in my diary and the teacher’s diary.

**Project 2: Assessment of daily caloric expenditure**

One month after completing the first project, the second project was introduced to the study cohort. The second project was designed as a follow-up to the first. Whereas students learned to be conscious of their calorie intake during the first project, the second project taught students to be conscious of their calorie expenditure. The second project challenged students to view their caloric intake in the context of their calorie expenditure and to use that information together to make more informed choices regarding nutrition and physical activity.

The objectives for the second session were:

- Introduction of the project’s overall purpose
- Development of student motivation
- Concept development
  - Activities that contribute to total metabolic expenditure
    - Resting metabolic expenditure
    - Volitional metabolic expenditure
    - Metabolic expenditure of digestion
  - Direct calculation of metabolic expenditure
• Calorimetry
  o Indirect calculations using proxies for metabolic activity and nomograms
    ▪ Height and weigh nomogram for estimating Resting metabolic expenditure and metabolic expenditure of digestion
    ▪ Using pedometers to estimate volitional metabolic expenditure
  o Discussion of potential sources of error using this indirect method
• Practice exercise
  o Each student calculates his/her resting and digestive metabolic rate using their height, weight and the nomogram
  o Students practice calculating volitional metabolic expenditure using simulated pedometer data
• Pedometer distribution and group exercise
  o Students and teachers walk a mile to calibrate pedometers and learn the concept of a mile
• Review of procedure to calculate caloric total expenditure for five days

After the students completed their calorie expenditure diaries, they were collected; and in a fashion similar to that used with the diet diaries, a histogram of calorie expenditure was generated of the class during the five day experiment. This histogram was overlayed with the histogram of calorie consumption and shared with the class. The assumption was that if students, on average, had caloric intakes that matched caloric expenditure, the two histograms should overlay without discrepancy. Students were challenged to identify scenarios where this logic would not apply. After reviewing the caloric expenditure data, the conversation was directed toward students’ response to the exercise. As a group, the class explored our perceptions regarding our activity levels before wearing a pedometer to our perception after viewing objective data on our activity level. Students were asked to compare their personal calorie consumption from the first exercise with their calorie expenditure from the
present exercise. Students discussed how this comparison could be helpful as well as weaknesses inherent is this type of comparison.

Psychosocial Considerations

These projects address issues that often contribute significantly to an adolescent’s self-image and self-esteem; namely: diet, exercise and weight. Surveys of adolescents’ perception of self indicate that 85% of adolescent females feel that their weight is important in their calculation of self-esteem. Up to 75% percent of adolescent females perceive themselves as fat. Recent work suggests that adolescent males commonly have significant feelings of dissatisfaction regarding their bodies with a significantly greater portion of dissatisfied males wanting thinner bodies than those wanting bulkier bodies. The implication diet, exercise and weight has on self-image makes their open discussion challenging, especially when the discussion is likely to identify dietary and exercise habits that may not be entirely healthy. These topics can be problematic for adolescents whose self-image is based largely on perceptions of their diet, physical activity level, weight and appearance.

Several accommodations were made in designing the projects to safe-guard the self-image of students and prevent the project from having a putative tone. With regard to the diet diaries, the winter holiday were intentionally selected as the time frame during which the diaries would be assigned. By selecting a period when it is customary to over-indulge, everyone had a plausible excuse for a calorie dense diet. When introducing the diaries to the class, the rationale for choosing the holidays for the diary was explained. Students were encouraged to use the experience to observe how easy it is to consume several servings of calorie dense foods, often in excess of what would be considered healthy simply because it is the holidays. The implication was that the information we would gather during the holidays from the diaries would represent atypical dietary habits that are not typical of day-to-day eating styles. Thus students, who would otherwise feel uncomfortable about the diary, could be at ease.
Having established that the setting for our diet diaries was not typical and was intentionally biased to produce the picture of overindulgence, a non-threatening environment was created wherein students could analyze and learn from their diaries. Students were encouraged to assess their diet over the holiday using guidelines developed by the American Heart Association. They calculated the fraction of calories derived from protein, fat and carbohydrate. They calculated their total daily calorie intake and compared it to recommendations based on their age, gender and height. Finally, they devised a list of suggestions to improve their diets. The students were coached to develop suggestions that were realistic and that allowed them to enjoy foods they liked.

The tone of the discussion regarding diet and exercise were always health positive and never health negative. The emphasis was always on encouraging a healthy lifestyle and never on discouraging or disparaging unhealthy lifestyles. Emphasis was placed on the benefits of healthy living and less so on the risks of unhealthy living. Students were encouraged throughout the discussions to share their thoughts, feelings and personal experiences. This was an important part of the session as it provided real-time feedback so that the session could be guided in a way that was sensitive to students’ concerns.

Likely one of the most important accommodations to protect students’ sense of self was the inclusion of teachers in the project. Mrs. Neighbors, the students’ teacher; Mrs. Coggins, the students’ principal and I completed diet diaries along with the students over the holidays and we also wore pedometers along with the students so that we could calculate our daily caloric expenditure during the second phase of the project. When we discussed our diet diaries, my diet diary was the only one that was publicly displayed. The students were asked to review the diary and point the areas of overindulgence. The teacher, principal and I performed the same health evaluation on our diaries that was assigned to the students and shared that with the class.
Teachers actively assuming the role of role-model is an important and often overlooked aspect of teaching. There is a growing body of evidence that supports the idea that health outcomes are improved among adolescents who have appropriate positive role models. We teachers, participating with our students in this way, created a less putative environment. No one’s diet was beyond constructive criticism and I think that our participation offered to the students a sense of fairness and underscored our goal of offering each other constructive feedback in learning healthier habits.

*The General Health Knowledge Assessment*

The General Health Knowledge Assessment (GHKA) was the central tool used to evaluate students’ health knowledge for the purpose of measuring the efficacy of the study curriculum compared to the standard health education curriculum in place at Career High School. The study cohort took this assessment before their exposure to the study curriculum. They took the assessment again nine months later after completing the study curriculum. The control cohort experienced the standard health education curriculum at Career High School without exposure to the study curriculum and took the GHKA once at the completion of their curriculum.

The GHKA is composed of 42 multiple choice items. The assessment probes knowledge in three content areas:

- The Doctor/Patient Encounter (7 question items)
- Health Maintenance (18 question items)
- Pathophysiology (17 question items)

The forty-two items were written with deference to standard conventions in multiple choice question writing with the understanding that among educators, an evidence based consensus on guidelines for multiple choice question writing has not been established. The entire forty-two item
assessment with items in the order that they were presented to students can be found in Appendix A. Below the items have been assembled by content area for reader review.

In writing the items, the target difficulty† of between 0.50 and 0.67 was desired knowing that pretest difficulty before study curriculum exposure would be closer to 0.50 and that posttest difficulty after exposure would be closer to 0.67. While the pretest and posttest are the same, the difficulty was expected to change because of an expected increase in students’ fund of knowledge as a result of exposure to curriculum content. The target difficulty was selected based on research showing that a target difficulty between 0.50 and 0.67 optimizes score reliability of multiple choice tests.75

† Difficulty is defined as the percentage (expressed as a decimal) of test takers who answer an item correctly. Thus an item difficulty of 1.0 indicates that all test takers answered the item correctly (an easy question).
The Doctor/Patient Encounter (7 items)

1. When a doctor measures your blood pressure, your doctor is measuring
   a. How fast your heart is beating.
   b. The health of vessels that carry blood.
   c. The force that blood exerts on the walls of veins.
   d. The force that blood exerts on the walls of arteries.
   e. The amount of blood in your body.

2. Medical problems you discuss privately with your physician
   a. Cannot be shared with others without your permission.
   b. Can be shared with your parents if they ask.
   c. Can be shared with your principal if you get sick at school.
   d. Are not confidential until you are 18 years old.

3. An EKG is used to measure activity of the
   a. Brain
   b. Lungs
   c. Heart
   d. Stomach

4. Which of the following is not a vital sign:
   a. Heat rate
   b. Respiratory rate
   c. Weight
   d. Blood pressure
   e. Temperature

5. When a doctor presses on a person’s abdomen, the doctor is
   a. Checking if the patient is ticklish.
   b. Checking if the stomach is full or empty.
   c. Checking the health of abdominal organs.
   d. Checking if the patient is overweight.

6. The rectal exam is used to
   a. To examine the prostate.
   b. Check for colon cancer.
   c. Check for bleeding in the gastrointestinal system.
   d. All of the above.

7. A stethoscope is used to
   a. Listen to the heart.
   b. Listen to the lungs.
   c. Listen to the abdomen.
   d. Check blood pressure.
   e. All of the above.

Health Maintenance (18 items)

1. Which of the following statements about cholesterol is NOT true:
   a. Cholesterol is commonly found in the American diet.
   b. Cholesterol is produced by the body.
   c. Cholesterol serves an important role in the body.
   d. A person with normal body weight cannot have high cholesterol.

2. High blood pressure can be caused by
   a. Inherited factors
   b. High salt diet
   c. Obesity
   d. All of the above

3. Select the group that has the highest risk for heart disease:
   a. People who have already had a heart attack.
   b. African-Americans in poor neighborhoods.
   c. African-Americans in rich neighborhoods.
   d. Caucasians in rich neighborhoods.
   e. Japanese adults.

4. Atherosclerosis is a disease that results in hardening and narrowing of the arteries. All of the following are correct about this disease EXCEPT:
   a. It is related to consuming foods high in fats for long periods of time.
   b. It does not begin in people less than 25 years.
   c. It takes years to develop.
   d. It usually does not produce symptoms in people less than 50 years old.

5. Which of the following is NOT effective in reducing the number of deaths from colon cancer:
   a. Avoiding diets high in saturated fats.
   b. Including high fiber foods in the diet.
   c. Avoiding beverages containing caffeine.
   d. Regular colon exams starting at age 50.

6. Colon cancer is a disease
   a. That often runs in families.
   b. Is more common among people who consume a high fat diet.
   c. Is usually treatable if detected early.
   d. All of the above.
7. Which of the following is LEAST likely to cause heart burn
   a. Eating a large meal.
   b. Lying down immediately after eating.
   c. Eating spicy food.
   d. Drinking alcohol before going to sleep.
   e. A heart attack.

8. Which of the following is NOT true about fiber
   a. Can be used as a source of energy during times of starvation.
   b. Is not digestible in humans.
   c. Can be found in certain fruits and vegetables.
   d. Protects against colon cancer.

9. Which of the following is LEAST likely to be the cause of food poisoning
   a. Undercooked meat or poultry products.
   b. Foods that have come in contact with uncooked meats or poultry.
   c. Poisons that have been added accidentally to foods.
   d. Refrigerated leftovers that have not been reheated.

10. Which of the following is NOT true about asthma
    a. More common in rural suburbs than in urban cities.
    c. More likely to be detected in children than in adults.
    d. More severe in homes with pets and carpet.

11. Which of the following is NOT a trigger for an asthma attack
    a. Exercise
    b. Dust
    c. Being sick with a cold
    d. A migraine headache

12. Asthma attacks are less likely when patients
    a. Remove carpeting from their homes.
    b. Do not own pets.
    c. Avoid exposure to cigarette smoke.
    d. Use their inhalers before exercise.

13. High blood pressure is dangerous because
    a. It increases a person’s risk for a stroke.
    b. It increases a patient’s risk for heart disease.
    c. It increases a patient’s risk for kidney disease.
    d. All of the above.

14. Being overweight increases the risk of which problem
    a. Cardiovascular disease
    b. Diabetes
    c. Joint and bone disease
    d. All of the above

15. A healthy approach to achieving a healthy body weight
    a. Daily exercise.
    b. Increasing fresh vegetable and fruit in the diet.
    c. Avoiding fried foods.
    d. Involving family member in healthy habits.
    e. All of the above.

16. The most effective way to prevent the spread of viruses and bacteria is
    a. Hand washing.
    b. Avoiding sick people.
    c. Wearing rubber gloves when cleaning.
    d. All of the above.

17. Birth control pills are effective at
    a. Preventing the transmission of syphilis.
    b. Preventing the transmission of gonorrhea.
    c. Preventing the transmission of Chlamydia.
    d. Preventing pregnancy.
    e. All of the above.

18. Gonorrhea can be transmitted by
    a. Unprotected oral sex.
    b. Unprotected vaginal sex.
    c. Unprotected anal sex.
    d. All of the above.
Pathophysiology (17 items)

1. Which of the following is the cause of drug resistant bacteria
   a. Improper use of antibiotics.
   b. Travel to foreign countries without the appropriate vaccinations.
   c. The discovery of mad cow disease.
   d. The spread of bird flu from China.

2. Which of the following in NOT true about cancer
   a. Cancer is an abnormal growth of the body's cells.
   b. Cancer can spread from one part of the body to another.
   c. Cancer can recur after being removed.
   d. Cancer is less likely to recur in patients who are given antibiotics.

3. Which of the following is LEAST likely to increase your heart rate:
   a. Fear
   b. Pain
   c. Sleep
   d. Visiting a doctor
   e. Dehydration
   f. Infection

4. Which of the following is NOT true about a heart attack:
   a. A heart attack is caused by an infection of the heart.
   b. A heart attack can cause chest pain.
   c. A heart attack is caused by reduced blood flow to heart muscle.
   d. A heart attack can cause death.

5. Which of the following nutrients can be used most readily by the body as an energy source?
   a. Vitamins
   b. Sugars
   c. Protein
   d. Fats
   e. Water

6. Uncontrolled diabetes can cause other health problems by
   a. Damaging blood vessels.
   b. Making weight loss difficult.
   c. Preventing red blood cells from obtaining oxygen in the lungs.
   d. Causing the digestive system to absorb too much glucose.

7. Insulin is produced by which type of cell?
   a. Islet cell in the pancreas
   b. Hepatocytes in the liver
   c. Myocytes in muscle
   d. Glial cells in the brain

8. Which of the following activities does NOT occur in the stomach:
   a. Churning of food.
   b. Absorption of nutrients.
   c. Destruction of bacteria contained in food.
   d. Acid production.

9. Bile is a substance produced by the liver and is responsible for
   a. Making fats more soluble in water.
   b. Absorbing sugar.
   c. Killing bacteria in food.
   d. Absorbing alcohol.
   e. All of the above.

10. A stomach ulcer is most often caused by
    a. Infection with bacteria
    b. Stress
    c. Overproduction of acid by the stomach
    d. Eating spicy foods
    e. Smoking

11. Which of the following does NOT occur during an asthma attack
    a. Plugging of airways with mucous.
    b. Spasm and constriction of airways.
    c. Oxygen content of the blood increases.
    d. Breathing rate increases.

12. The benefits of quitting smoking begin
    a. Within a day of quitting.
    b. Within a month of quitting.
    c. Within a year of quitting.
    d. Within five years of quitting.

13. The common cold is caused by
    a. Germs
    b. Viruses
    c. Bacteria
    d. Cold weather
    e. All of the above

14. Herpes is a sexually transmitted disease caused by
    a. A virus and CAN be cured with medication.
    b. A virus and CANNOT be cured with medication.
    c. A bacteria and CAN be cured with medication.
    d. A bacteria and CANNOT be cured with medication.
15. A cold caused by a virus
   a. Will get better faster if antibiotics are used.
   b. Will get better slower if antibiotics are used.
   c. Should not be treated with antibiotics because they have no effect on viruses.
   d. Should be treated with antibiotics only if the patient is very young or very old.

16. Antibiotics are medications that
   a. Kill viruses
   b. Kill bacteria
   c. Kill both viruses and bacteria
   d. Cause the body to form antibodies against bacteria

17. Which of the following is NOT true about antibiotic resistant bacteria
   a. They are new species of bacteria that are being discovered for the first time.
   b. They are common bacteria that have become immune to antibiotics.
   c. They are capable of causing death.
   d. They are commonly found in hospitals.

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Unit Pre and Post Tests

The GHKA was designed as a global assessment of health knowledge germane to the teaching objectives of the study curriculum. Proctoring the GHKA to both the study and control cohorts allows the efficacy of the study curriculum to deliver health knowledge to students compared to the control experience. As a broad survey of health knowledge, one of the practical limitations of the GHKA is its lack of detail, making it a coarse tool, at best, for evaluating the performance of each of the five curriculum units. To study each curriculum unit with greater specificity, unit specific assessments were developed. These assessments were proctored before and after each unit using pre and post test methodology. Comparing pretest and posttest performance, the relative effectiveness of each curriculum unit could be measured.

The pretest was proctored using Blackboard the week prior to the beginning of the unit. The same items were used for the posttest which was proctored a month later. Students received tailored feedback immediately after submitting their assessment for both the pretest and the posttest. The pre/post tests for each of the five units can be found in Appendix C.
Selection of control and study cohort

Overview

All of the students enrolled in this study attended Career High School located in New Haven during the study period from September 2004 through June 2005. Career High School is designated as a Regional Magnet High School. The school census at the time of the study was 710 students, of whom 61% were female and 39% were male. Career serves a predominantly African-American and Hispanic student body: 58% of students identify as African-American, 22% as Hispanic, 17% as white and 1% identify as part of other racial groups.

The study cohort was comprised of 41 students. The control cohort was comprised of 31 students. Due to scheduling limitations, randomization was not possible. Consequently, when comparing the two cohorts before intervention, a statistically significant difference in academic ability was noted when comparing standardized test scores (Table 5). Because this difference in academic ability is roughly consistent throughout all subject areas, it is possible to use regression analysis to attempt to correct for this difference when comparing performance between the two cohorts on study related assessments.

Table 5  Control vs Study cohort Pre-Study characteristics

<table>
<thead>
<tr>
<th></th>
<th>Control Cohort</th>
<th>Study Cohort</th>
<th>P</th>
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</thead>
<tbody>
<tr>
<td>Age</td>
<td>16.50yrs</td>
<td>16.47yrs</td>
<td>0.79</td>
</tr>
<tr>
<td>CAPT† Math Score</td>
<td>2.80</td>
<td>3.37</td>
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<tr>
<td>CAPT Science Score</td>
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<td>CAPT Reading Score</td>
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<tr>
<td>CAPT Writing Score</td>
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<td>4.00</td>
<td>0.0014</td>
</tr>
</tbody>
</table>

† Connecticut Academic Performance Test (CAPT) This exam is a standardized comprehensive statewide assessment of academic proficiency. Students are tested in the 10th grade and scores are reported in each content area on a scale from 1 through 5, where a score of 3 is considered a passing score (termed “proficient” by the Board of Education). Scores greater than three represent performance above the passing threshold and scores below three indicate performance below passing threshold.
While randomizing students to the control versus study cohorts is the optimal study design, the disruption that this would have caused in terms of adjusting students’ schedules according to randomization made this option incompatible with needs of the school. Instead, students who elected to enroll in an anatomy course were included in the study cohort while students who elected to enroll in a business course were included in the control cohort. Because students in each cohort elected to be in their respective cohort, it was assumed that motivational bias was the same in each group. What differed was curriculum content.

**Informed assent from students and informed consent from parents**

In accordance with standard protocols for studies that involve human subjects, this project was submitted to the Yale Human Investigations Committee for review prior to beginning the study. The committee determined that since identifying data was never collected in the study and because the nature of the survey items did not address personal or sensitive topics, specific HIC approval was not necessary. Nonetheless, it seemed prudent to seek informed consent from parents and informed assent from students since the students were participating in a research project. Furthermore, enrolled students would visit Yale’s Human Anatomy labs and providing parents and students with information regarding lab safety and potential risks is the ethically responsible thing to do. This consent/assent process included opportunities for students and parents to ask questions and to opt out at any time.

A consent team composed of a senior faculty member (Dr. Stewart), Principal of Career High School (Rose Coggins) and the investigator (the author), held a meeting with parents of students who were offered enrollment in this project. The consent team, lead by the senior faculty member reviewed the screening protocols that ensure that cadavers free of HIV, Hepatitis and other significant pathogens. The antimicrobial properties of the preservation process were reviewed as a second safety measure.
The use of universal precautions was described as the third layer of safety in the lab. The team informed parents and students that the most common, albeit rare, adverse effect of students in the lab is psychological discomfort with the experience. The support network in place to identify students who may feel uncomfortable with the experience and resources available to address their feelings were reviewed. The team reiterated that the student could opt out at anytime without any penalty. Parents also had the power exclude their child from the study at any time. Adequate time was allotted for questions. Student assent and parental consent was documented by signature on respective assent and consent forms that outlined the major points of discussion and provided contact information for the senior faculty member and the Principal.

Students in the control cohort did not visit the anatomy lab and only completed health knowledge surveys. For this reason they received an abbreviated assent discussion. Parents were informed about the project via letters sent home with students. Students were allowed to complete the health knowledge survey in accordance with protocol only if they returned a signed consent form from their parents and signed an assent form themselves.

**Curriculum implementation and assessment**
First year medical student teachers were recruited as teachers of the study curriculum during an information session that was held in September. Dr. Stewart announced the opportunity during one of his first anatomy lectures to the class. He explained the goals of the project and offered it to the students as an opportunity to review their anatomy skill while contributing to the community at the same time. Interested students attended an informal information session conducted by Dr. Stewart and me along with two second year medical students who had participated in ATP the year prior, before the formalized curriculum and study protocol had been designed.
At the meeting the ATP alums explained the program and its personal rewards. I introduced the study to the students as an attempt to objectively measure the success of a program whose merit heretofore has only been described anecdotally. I explained the teaching style used in the curriculum and made the lesson plans as well as the assessments that the high school students would be taking available to the teachers on the anatomy website.

**Data analysis**

Data was analyzed using intention to treat methodology. Data from all students enrolled in the study was used regardless of whether they were present for all sessions or dropped out along the way. Only one student in the study cohort failed to complete the program because the student left the school entirely. Of the remaining students, occasional gaps in the data set were observed as a result of random absenteeism on testing days. There was no regular pattern of absenteeism, so the effect of absenteeism is expected to be negligible. Scores were not eliminated if a corresponding pre or post test scores was missing. To do so would have introduced the potential for exclusion bias. If there was a correlation between students who missed a pre or post test and their academic performance, that relationship would be lost if those data points were systematically eliminated.

When comparing pre and post test performance, cohort scores were averaged using Microsoft Excel. T-test analysis to identify statistically significant differences in performance was performed using the Student T-test loaded into Microsoft Excel.
RESULTS

Overview

The objective of this study is to determine whether an interactive health education curriculum that utilizes as its primary teaching device, exploration of the human body in the anatomy lab, is effective in improving participants’ health knowledge. The primary measure of the curriculum’s effectiveness is pre and post assessment of students’ health knowledge using computerized multiple choice exams. Comparison of students’ pre exposure knowledge level to their post exposure knowledge level should give a rough estimate of the curriculum’s effectiveness. To control for the possibility that a measured effect is attributable to life experience outside of the study curriculum, the performance of the study cohort was compared to that of their peers in the control cohort who had not been exposed to the study curriculum but instead had been involved in intensive exposures business administration.

The pre/post measurement was comprised of two measurement tools. The first measurement tool was a 42 item test of general health knowledge (termed the General Health Knowledge Assessment, or GHKA) which was administered before the intervention in October and then again after the intervention in May. The tool was described in detail in the Methods section. A reprint of the tool can be found in Appendix A. The second measurement tool was composed of five unit tests which were designed to measure specific health knowledge germane to the five topics covered by the curriculum. These five unit tests were administered before and after each topic areas were taught. The washout period between the pre and post administration was uniformly one month.

The control cohort was surveyed with the GHKA only. This cohort did not require detailed analysis with the individual unit tests. It was assumed that the GHKA would provide a sufficient measure of
students’ general health knowledge making more detailed analysis unnecessary. This cohort was assessed once in May.

The execution of the assessment protocol yielded the following results:

- Students exposed to the study curriculum experienced a statistically significant improvement in their overall health knowledge as measured by the Pre/Post GHKA.
- Students exposed to the study curriculum demonstrated statistically significant improvement in each of the three content areas assessed by the GHKA.
- For each of the curriculum topics, exposed students demonstrated a statistically significant improvement in detailed health knowledge as measured by unit-specific pre/post tests.
- Students exposed to the study curriculum demonstrated a greater fund of health knowledge compared to students who did not participate in the study curriculum.
- Students exposed to the study curriculum demonstrated a fund of knowledge in each of the three GHKA content areas was more robust than students who were not exposed to the study curriculum.

Pre/Post GHKA Data among the Study Cohort
The original study cohort contained 41 students. After enrollment, one student moved away and thus only forty students took the October proctoring of the GHKA. Thirty-eight students completed the May proctoring of the GHKA. The two missing data points are the result of two students who were absent for the May proctoring and who also did not attend the make-up proctoring. Their absence at the post test survey resulted in two unpaired data-points. Despite their absence, these two students’ pre test scores were included in the data analysis based upon the intention-to-treat data analysis model.
Figure 1 illustrates the average performance of the forty students who took the October proctoring of the GHKA compared with the performance of the thirty eight students who completed the May proctoring. The average number of items answered correctly by students during the October proctoring and before exposure to the study curriculum was 53.2%. The average item difficulty was 0.56. The average score after the intervention when the GHKA was re-administered in May was 66.7%; a statistically significant improvement, p < 0.001.

Study Cohort, General Health Knowledge Assessment
Overall Performance
Washout between Pre and Post Tests = 7 months

Study Cohort Performance on GHKA by Content Area
The items in the GHKA measured knowledge in three content areas:

- Pathophysiology
- Health Maintenance
- The Doctor Patient Encounter
The assessment items for each content area can be found in the Methods section. In addition to obtaining an overall score, each exam was scored by content area so as to get a more complete understanding of students’ health knowledge.

Figure 2 illustrates students’ performance in each of the three content areas before and after exposure to the study curriculum. The figure shows that students’ knowledge improved significantly in each of content areas ($p < 0.005$). Student improvement was the greatest in pathophysiology (average score improved 18 percentage points) and the least in health maintenance (average score improved 8 percentage points).

![Study Cohort, General Health Knowledge Assessment Performance by Content Area](image)

**Study Cohort Performance on Topic Pre/Post Tests**

The study curriculum consisted of the following five topics:

- Lab 1: Surface anatomy and the physical exam
• Lab 2: Cardiovascular disease and the cardiovascular exam
• Lab 3: Energy management
• Lab 4: Infectious disease
• Lab 5: Diagnostic testing

The impetus for selecting these five topics for inclusion in the curriculum is described in the Methods section. The specific teaching objectives for each of the sessions are summarized in the lesson plans located in Appendix B.

Each topic was taught over a four week period during two, hour-long sessions, every other week in the Yale Anatomy lab. The sessions were taught by first year medical students. Before the beginning of each unit, students took the topic pretest on computers at Career High. Thereafter they received worksheets that prepared them for the two upcoming sessions. The week after the second session, students took the post test, again using computers at Career High. The time period between pre and post examination was uniformly four weeks for each topic.

Figure 3 compares students’ pretest performance to their posttest performance for each of the five topics (labs). For each proctoring an average of 38 students sat for the assessment. Absent students account for missing data points. There was no observable trend or pattern in student absenteeism and therefore the effect of absenteeism on data analysis is assumed to be insignificant.
Pre and posttest assessment of student health knowledge show a statistically significant ($p \leq 0.001$) improvement in fund of health knowledge after completing each unit compared to their knowledge base before exposure to topic content. The largest improvement in knowledge base was observed with Lab 2: Cardiovascular disease and the cardiovascular exam. On average, student performance improved by more than 25% from pretest to posttest. The smallest improvement was noted on Lab 1: Surface anatomy and the physical exam.

Pretest performance on all topics except Lab 1 were within the range of 45 to 60 percent indicating a test difficulty level that is optimal for measuring improvement or deterioration of knowledge base (see Methods for description of optimal difficulty goals for measuring change in knowledge base). Students’ high pretest performance in Lab 1(surface anatomy and the physical exam) reflects students’ strong knowledge base prior to exposure to Lab 1 material. The small improvement observed with Lab 1 relative to the improvement observed in the other labs may indicate less
effective content delivery or insufficiently sophisticated content compared to students’ level of knowledge. Alternatively, the relatively small improvement in performance may be an artifact of the lab 1 pre/post test whose difficulty (as evidence by the high pretest performance) was sub-optimal. The resolution of exams to detect difference in funds of knowledge decreases at the extreme ends of the difficulty scale. It is possible that the magnitude of the improvement observed in lab 1 would have been comparable to that observed in the other labs if a pre/post exam of optimized difficulty was employed.

**GHKA Performance, Study Cohort vs Control Cohort**

The limitation of using the pre/post model for assessing curriculum efficacy is does not control for the possibility that the observed change in knowledge may be the result of experiences that the student has had outside of the study environment. Using this study as an example, there is no way to know, using the pre/post data alone, whether the measured gains in knowledge are the result of the curriculum or if the students happened to learn the material through some other channel outside of the classroom. To control for this, we tested the knowledge base of a comparable cohort of students in the same high school, of the same grade level and of the same academic caliber. The students in this control cohort were not exposed to the study curriculum. If the curriculum was responsible for teaching health knowledge and not some other source, then it was expected that the study cohort will outperform the control cohort due to their unique access to information contained within the study curriculum.

Figure 4 compares the study cohorts’ posttest performance on the GHKA with the performance of control cohort on the GHKA. Both cohorts took the assessment at the same time and thus their life experience with the exception of their exposure to the study curriculum was roughly the same. Figure 4 shows that students exposed to the study curriculum had a broader fund of health knowledge,
scoring an average of 66.73%, compared to comparable students who had not been exposed to the study curriculum and scored on average, 47.31% (p < 0.001). This comparison suggests that the improvement in fund of health knowledge observed with pre/post testing among the study cohort is unlikely to be the result of other life experience since comparable peers did not exhibit a fund of health knowledge comparable to students who were exposed to the study curriculum.

**GHKA performance, Study vs Control Cohort, by Content Area**

Beyond comparing the overall average score of study students to control students, the study cohort average performance on each of the three content areas measured by the GHKA was compared to the average performance by the control cohort on each of these areas. This comparison allows me to determine whether the gains in each of these three areas see on pre/post test analysis are all attributable to the curriculum or if one or more are the result of life experience.
Figure 5 illustrates the average performance of the study cohort on the GHKA by content area compared to the average performance of the control cohort on the GHKA by content area. The figure shows that in each of the content areas, students who were exposed to the study curriculum had a more robust fund of knowledge than students who were not exposed to the curriculum (p < 0.001). It is therefore unlikely that life experience significantly contributed to gains observed in any of the three measured content areas using the pre/post test assessments.
DISCUSSION

Overview

The goal of this study was to develop and test a novel high school health education curriculum. The primary measure of effectiveness was pre and post test analysis where each student acted as his/her own control. Students exposed to the new curriculum demonstrated a statistically significant improvement in their fund of health knowledge at the end of the course compared to the beginning. To control for the possibility that students’ increased health knowledge may have been acquired elsewhere, the students’ post intervention performance was compared to an age matched cohort of students who were not exposed to the study curriculum. Students exposed to the study curriculum demonstrated a fund of knowledge that was more robust than age matched controls.

It is important to note that proving that the study curriculum improves health knowledge is not equivalent to proving that the study curriculum improves health behavior or health outcomes. A separate study is required to investigate the later objectives. Initiatives to demonstrate curriculum effectiveness on health behaviors and outcome have traditionally required large cohorts in order to achieve statistical significance. In order to justify exposure of larger numbers of Career High School students to the study curriculum it was necessary to demonstrate that exposure to the curriculum was a worthwhile learning experience. It is the hope that the data presented here will satisfy the academic requirements of new curricula at Career and thus allow for a broader implementation of the curriculum along with the pursuit of answers to more ambitious research questions.

This project demonstrates that an anatomy based health education curriculum may improve students’ health knowledge when applied broadly to a student population at Career High School. The preliminary data generated here warrants more thorough investigation of the curriculum’s potential to
increase health knowledge. Of equal importance is determining whether the curriculum has an impact on students’ attitudes toward health behavior and their actual behavior patterns.

The primary limitation of the study is the absence of a control cohort that is directly comparable to the study cohort. While both cohorts were age matched, there were statistically significant differences in their academic ability based on standardized test scores. Second, a baseline health knowledge assessment was not completed with the control cohort. To validate the data generated by this project, a more comparable control cohort is needed and that cohort should be assessed twice, once in the beginning of the academic year and again at the end to mirror the pre and post assessments taken by the study group.

**Limitation in Method**
Because the study curriculum was deployed in a high school and not in an educational laboratory the curriculum had to be designed and deployed in a way that maintained the scientific integrity of the project without obstructing or interfering with the educational mission of the high school. The interplay between these two objectives was most apparent when the two objectives were in opposition. The most significant of these conflicts was with access to a sufficient number of students to lend statistical weight to the study. Another conflict was found in assembling two cohorts of students who are similar in all respects except for their exposure to the study curriculum versus the standard Career High School health curriculum which served as a control.

Whereas I would have preferred to randomize the entire Junior class to either the control or study curriculum, there were significant logistical and administrative obstacles to this approach. First, because this new curriculum had never been tested, it was agreed that it would be unwise to expose half of the Junior class to an untested curriculum. Second, limitations in financial and human resources for this project would have prevented such a large scale endeavor. For this reason it was
agreed that a small pilot group of students would be selected to test the curriculum, this approach closely approximates the standard evaluation protocols for new high school curricula.

Between the Principal and the research team, we agreed that a test group of forty students would be feasible allowing us to effectively deploy the curriculum without disrupting high school function. Initially, I proposed the idea of randomly selecting students for the test curriculum. This idea was not feasible because it would require individually rescheduling forty students’ schedules so that they could participate in the study curriculum. Instead, the school administration suggested that we enroll, en bloc, two sections of science elective students. This would eliminate the need to reschedule student programs. It was agreed that the two sections of students who were taking the Anatomy and Physiology elective would serve as our test group. A natural objection to this decision would be that selecting students taking an anatomy course would obfuscate our results, making it impossible to determine whether our measured effect was the result of our curriculum or the anatomy curriculum. This criticism is dampened by considering the objectives of our curriculum, the objectives of the anatomy curriculum that the students were concurrently enrolled in and what our assessments were measuring. Whereas the high school curriculum was designed to leave students with an understanding of human anatomy without any health correlation, our curriculum was not interested in retention of anatomical knowledge but instead used cadavers as a teaching tool to demonstrate concepts in human health and disease. The content assessments associated with this curriculum reflect its focus on behavior, health and disease. In other words, while the high school anatomy curriculum focused on achieving mastery of anatomical concepts, our students were tested on their ability to master health concepts that were not part of the high school anatomy curriculum.

When testing new curricula, there are several methods of controlling the test. Each method has its practical and scientific advantages and disadvantages. A common method of assessing content delivery is by comparing pre and post test performance. In this design, each student acts as his/her
own control. The primary advantage of using a self controlled protocol is that each subject is a
perfect match in terms of social, demographic and other attributes that cannot be perfectly replicated
in even the most rigorously assembled control cohort. The limitation of self control in the evaluation
of new curricula is that this approach does not rule out the possibility that any content gained by the
subjects could have been the result of some other life experience that the subjects have had outside of
the curricular exposure.

To address this criticism, an additional control using a dedicated control cohort that did not
experience the study curriculum was employed. The ideal control would be students of the same
academic level in the same high school whose academic exposure was the same in every aspect
except for their exposure to the study curriculum. In this case, the ideal control cohort would be
Juniors who were enrolled in the same anatomy course that the study subjects were taking. There are
forty students who met these criteria. Dividing this group into two cohorts was not feasible for two
reason: 1) cohorts of 20 students each were unlikely to produce a data set of adequate robustness to
afford statistical significance; 2) dividing the class into two groups where one group would have the
opportunity to visit an anatomy lab could potentially give those students an advantage on exams that
they would all take to pass their high school anatomy elective compared to students who did not have
the opportunity to visit our lab.

Unable to split the class of 40 anatomy students in half, the next best option was to recruit a cohort of
students with a similar academic profile. The best control cohort that could be constructed given the
limitations described was forty Juniors from Career High School business track whose core academic
experience was the same as the students in the study cohort except for the electives that they took.
Potential benefits of hands-on student-centered teaching
The pedagogical approach that makes the study curriculum unique is the emphasis on learning through exploration and a student driven learning experience. The central element of this exploratory approach is use of the anatomy lab at the Yale School of Medicine as the primary learning environment. While the choice to use cadavers as a teaching tool for adolescents may seem unorthodox, objective data assessing the utility of guided tours for high school students of Yale’s anatomy lab students showed students benefited academically from the exposure, especially those who were concurrently taking an anatomy course that did not normally involve visits to an anatomy lab. This data was generated during the ten years that the Yale Anatomy lab has offered guided tours to New Haven’s high school students. Furthermore, subjective data collected from teachers who witnessed the visits showed that the students’ interest level and attention were greater during the visits than when similar material was presented to them in classrooms at their respective schools. Most importantly, students who had visited the lab on informal tours overwhelmingly found the visits beneficial and worthwhile even if they had doubts before the visit. Thus, the anatomy lab was an obvious location for the teaching of health education because of the utility of having cadavers available for teaching health concepts and because students appeared to be highly motivated and attentive while in the lab.

The availability of several cadavers and first year medical student facilitators allowed small group learning to be a central part of the educational experience. The typical small group contained about 6 students. The benefits of small group learning are well established and include the ability of the instructor to assess comprehension among all of his/her students in real time by asking questions directly of students while still having ample time for teaching. The small groups create an environment wherein students have greater involvement in the learning process. Students receive more tailored and detailed feedback as the instructor can afford to dedicate more time to each student.
Furthermore, the small group creates a social support network for students especially at the beginning of the curriculum as students become acclimated to working in an anatomy lab.

This student focused approach represents a significant change from the teacher centered approach commonly used in the teaching of health education wherein the teacher’s role as a source of information is emphasized and the teacher directly imparts knowledge to students through lecture style lessons. Our curriculum avoids the direct teaching model and instead relies heavily on learning by discovery while in the anatomy lab. Anatomy faculty and first year medical students act as facilitators of student learning by asking students questions to probe their understanding. New information is introduced through problems presented by the facilitators. Using their current knowledge, students are challenged to propose mechanisms by which organ system dysfunction results in disease; furthermore, students are asked to describe how behavior can modify or cause organ dysfunction. After proposing a mechanism, students are challenged to prove their solution using the cadaver. When confronting the cadaver, students are encouraged to modify their solution if the information contained in the cadaver suggests that their solution was incomplete or incorrect. The facilitator ensures reinforcement of the solution by having a student demonstrate the solution to the rest of the group while using the cadaver as an illustration.

Using first year medical students as the primary teachers of the curriculum was intended to make the material more accessible to students as well as provide role models whom the students were likely to respect. First year medical students have two important advantages as teachers that the curriculum takes advantage of. Because of their status as future doctors, high school students are quick to ask questions as they view the students as sources of knowledge. This is evidenced by observations over the ten years that students have informally visited the lab and the detailed and often personal questions that students ask. Second, first year medical students young age relative to their other teachers gives them a psychosocial advantage, as they more recently had the experience of being
adolescents compared to older instructors. For this reason, first year medical students are commonly looked upon as role models by high school students.

The curriculum was designed to create an environment wherein healthy behaviors were viewed in a positive light by teachers and students alike. In the anatomy lab for example, emphasis was not placed on the shock value of showcasing cadavers that suffered from behavior related disease. Instead, cadavers were selected in such a way as to demonstrate the spectrum of organ system health from the healthy to the diseased state. Emphasis was placed on comparing organ systems between cadavers and exploring the environmental and behavior factors that mediate the differences that were observed. In this way, the experience in the lab was designed to give students an appreciation for what our bodies do for us on an ongoing basis, and students came to appreciate each of has an active role in the condition of our bodies. Students left the lab understand how behavior impacts organs systems and were thus empowered to make healthy decisions.

Having demonstrated in the lab the role of behavior on the integrity of the body’s organ systems, students were given the opportunity to assess their own health behaviors and make decisions on how they could be better to their bodies. The students participated in two health projects. In the first project students learned how to maintain a diet diary. The objective of the project was three-fold: 1) students learned in specific terms what a “balanced diet” is 2) students learned how to assess the nutritional value of the foods they consumed 3) students learned how to make use of nutrition information panels on the packaging of products they plan to consume. Care was taken to ensure that the project did not appear punitive. The goal of this project was not to seek out students who had a poor diet. Instead the project’s main aim was to remove obstacles toward practicing a healthy lifestyle by providing students with the both the tools and the opportunity to use those tools toward more healthy behavior.
Future endeavors
Using a small cohort of participants, this project piloted a novel health education curriculum that experiences in the Yale anatomy lab as a vehicle to improve understanding of the human body and behaviors that modify its health. Several curriculum attributes make this exposure different from standard health education programs:

- Anatomically based curriculum
- Student centered learning
- Emphasis on providing role models
- Opportunities to practice health behaviors
- Teacher participation in group activities, projects and health exercises

Whereas many studies attempt to identify single curriculum elements that are responsible or necessary for improvements in health knowledge and health behavior, this project worked on the assumption that a successful curriculum must utilize a variety of interlocking mechanisms to successfully impact students. Some of these mechanism address the diversity of learning styles that are expected within any given class, other mechanisms were targeted at motivation and still others were aimed at providing positive role models.

This project suggests that this holistic approach to health education hold promise in improving students’ health knowledge. Career High School is committed to further development and study of this new health education program. The following are broad research goals regarding the further study of this program:

- Definitive demonstration of knowledge benefit of exposure to study curriculum
  - Larger study and control cohorts
  - Randomized cohorts with comparable academic attributes
- Assessment of impact of curriculum on attitudes toward health behavior
- Psychosocial assessment of students' attitudes before and after curriculum exposure
- Psychosocial assessment of control cohort before and after control exposure
- Assessment of curriculum impact on health behavior
  - Survey of students’ health behaviors (especially dietary and exercise habits) before and after curriculum exposure
  - Similar surveying of control cohort before and after control exposure

Demonstrating a positive effect on attitudes toward health behavior as well as actual behavior would potentiate a rigorous investigation to expose the curriculum elements that are responsible for the measured benefit. Identifying these elements would allow for the systematic adaptation of the prototype curriculum so that it could be effectively transplanted to other schools.


76. Stewart W. Yale University School of Medicine; 2001.
Appendix A

General Health Knowledge Assessment (GHKA)
<table>
<thead>
<tr>
<th>Question 1</th>
<th>Multiple Choice</th>
<th>1 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which of the following statements about cholesterol is NOT true:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Cholesterol is commonly found in the American diet.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Cholesterol is produced by the body.</td>
<td></td>
<td></td>
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<tr>
<td>☐ Cholesterol serves an important role in the body.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ A person with normal body weight cannot have high cholesterol.</td>
<td></td>
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<table>
<thead>
<tr>
<th>Question 2</th>
<th>Multiple Choice</th>
<th>1 points</th>
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</thead>
<tbody>
<tr>
<td>When a doctor measures your blood pressure, your doctor is measuring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ How fast your heart is beating.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ The health of vessels that carry blood.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ The force that blood exerts on the walls of veins.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ The force that blood exerts on the walls of arteries.</td>
<td></td>
<td></td>
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<tr>
<td>☐ The amount of blood in your body.</td>
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<thead>
<tr>
<th>Question 3</th>
<th>Multiple Choice</th>
<th>1 points</th>
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</thead>
<tbody>
<tr>
<td>Which of the following is LEAST likely to increase your heart rate:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Fear</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Pain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Sleep</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Visiting a doctor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Dehydration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Infection</td>
<td></td>
<td></td>
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<thead>
<tr>
<th>Question 4</th>
<th>Multiple Choice</th>
<th>1 points</th>
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</thead>
</table>
High blood pressure can be caused by

- Inherited factors
- High salt diet
- Obesity
- All of the above

**Question 5 Multiple Choice**
Which of the following is NOT true about a heart attack:

- A heart attack is caused by an infection of the heart.
- A heart attack can cause chest pain.
- A heart attack is caused by reduced blood flow to heart muscle.
- A heart attack can cause death.

**Question 6 Multiple Choice**
Select the group that has the highest risk for heart disease:

- People who have already had a heart attack.
- African-Americans in poor neighborhoods.
- African-Americans in rich neighborhoods.
- Caucasians in rich neighborhoods.
- Japanese adults.

**Question 7 Multiple Choice**
Atherosclerosis is a disease that results in hardening and narrowing of the arteries. All of the following are correct about this disease EXCEPT:

- It is related to consuming foods high in fats for long periods of time.
- It does not begin in people less than 25 years.
- It takes years to develop.
- It usually does not produce symptoms in people less than 50 years old.
**Question 8**  Multiple Choice  
Which of the following nutrients can be used most readily by the body as an energy source?  
- [ ] Vitamins  
- [ ] Sugars  
- [ ] Protein  
- [ ] Fats  
- [ ] Water

**Question 9**  Multiple Choice  
Uncontrolled diabetes can cause other health problems by  
- [ ] Damaging blood vessels.  
- [ ] Making weight loss difficult.  
- [ ] Preventing red blood cells from obtaining oxygen in the lungs.  
- [ ] Causing the digestive system to absorb too much glucose.

**Question 10**  Multiple Choice  
Insulin is produced by which type of cell?  
- [ ] Islet cell in the pancreas  
- [ ] Hepatocytes in the liver  
- [ ] Myocytes in muscle  
- [ ] Glial cells in the brain

**Question 11**  Multiple Choice  
Which of the following activities does NOT occur in the stomach:  
- [ ] Churning of food.  
- [ ] Absorption of nutrients  
- [ ] Destruction of bacteria contained in food.  
- [ ] Acid production.
<table>
<thead>
<tr>
<th>Question 12</th>
<th>Multiple Choice</th>
<th>1 points</th>
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<tbody>
<tr>
<td>Bile is a substance produced by the liver and is responsible for</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Making fats more soluble in water.</td>
<td></td>
<td></td>
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<tr>
<td>☐ Absorbing sugar.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Killing bacteria in food.</td>
<td></td>
<td></td>
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<tr>
<td>☐ Absorbing alcohol.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ All of the above.</td>
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<thead>
<tr>
<th>Question 13</th>
<th>Multiple Choice</th>
<th>1 points</th>
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</thead>
<tbody>
<tr>
<td>Which of the following is NOT true about fiber</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Can be used as a source of energy during times of starvation.</td>
<td></td>
<td></td>
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<tr>
<td>☐ Is not digestible in humans.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Can be found in certain fruits and vegetables.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Protects against colon cancer.</td>
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<tr>
<th>Question 14</th>
<th>Multiple Choice</th>
<th>1 points</th>
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<tbody>
<tr>
<td>Which of the following is NOT effective in reducing the number of deaths from colon cancer:</td>
<td></td>
<td></td>
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<tr>
<td>☐ Avoiding diets high in saturated fats.</td>
<td></td>
<td></td>
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<tr>
<td>☐ Including high fiber foods in the diet.</td>
<td></td>
<td></td>
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<tr>
<td>☐ Avoiding beverages containing caffeine.</td>
<td></td>
<td></td>
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<tr>
<td>☐ Regular colon exams starting at age 50.</td>
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<thead>
<tr>
<th>Question 15</th>
<th>Multiple Choice</th>
<th>1 points</th>
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</thead>
<tbody>
<tr>
<td>Colon cancer is a disease</td>
<td></td>
<td></td>
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<tr>
<td>☐ That often runs in families.</td>
<td></td>
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<tr>
<td>☐ Is more common among people who consume a high fat diet.</td>
<td></td>
<td></td>
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<tr>
<td>☐ Is usually treatable if detected early.</td>
<td></td>
<td></td>
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<tr>
<td>☐ All of the above.</td>
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</tbody>
</table>
Question 16  Multiple Choice  1 points
Which of the following is LEAST likely to be the cause of food poisoning

- Undercooked meat or poultry products.
- Foods that have come in contact with uncooked meats or poultry.
- Poisons that have been added accidentally to foods.
- Refrigerated leftovers that have not been reheated.

Question 17  Multiple Choice  1 points
A stomach ulcer is most often caused by

- Infection with bacteria
- Stress
- Overproduction of acid by the stomach
- Eating spicy foods
- Smoking

Question 18  Multiple Choice  1 points
Which of the following is LEAST likely to cause heart burn

- Eating a large meal.
- Lying down immediately after eating.
- Eating spicy food.
- Drinking alcohol before going to sleep.
- A heart attack.

Question 19  Multiple Choice  1 points
Which of the following is NOT true about asthma

- More common in rural suburbs than in urban cities.
- More common among African-Americans than among Caucasians.
- More likely to be detected in children than in adults.
- More severe in homes with pets and carpet.
Question 20  Multiple Choice  1 points
Which of the following is NOT a trigger for an asthma attack

- Exercise
- Dust
- Being sick with a cold
- A migraine headache

Question 21  Multiple Choice  1 points
Which of the following does NOT occur during an asthma attack

- Plugging of airways with mucous.
- Spasm and constriction of airways.
- Oxygen content of the blood increases.
- Breathing rate increases.

Question 22  Multiple Choice  1 points
Asthma attacks are less likely when patients

- Remove carpeting from their homes.
- Do not own pets.
- Avoid exposure to cigarette smoke.
- Use their inhalers before exercise.
- All of the above.

Question 23  Multiple Choice  1 points
High blood pressure is dangerous because

- It increases a person’s risk for a stroke.
- It increases a patient's risk for heart disease.
- It increases a patient’s risk for kidney disease.
- All of the above.
<table>
<thead>
<tr>
<th>Question 24</th>
<th>Multiple Choice</th>
<th>1 points</th>
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</thead>
<tbody>
<tr>
<td>The benefits of quitting smoking begin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Within a day of quitting.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Within a month of quitting.</td>
<td></td>
<td></td>
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<tr>
<td>☐ Within a year of quitting.</td>
<td></td>
<td></td>
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<tr>
<td>☐ Within five years of quitting.</td>
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<thead>
<tr>
<th>Question 25</th>
<th>Multiple Choice</th>
<th>1 points</th>
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</thead>
<tbody>
<tr>
<td>Medical problems you discuss privately with your physician</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Cannot be shared with others without your permission.</td>
<td></td>
<td></td>
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<tr>
<td>☐ Can be shared with your parents if they ask.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Can be shared with your principal if you get sick at school.</td>
<td></td>
<td></td>
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<tr>
<td>☐ Are not confidential until you are 18 years old.</td>
<td></td>
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<thead>
<tr>
<th>Question 26</th>
<th>Multiple Choice</th>
<th>1 points</th>
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<tbody>
<tr>
<td>Being overweight increases the risk of which problem</td>
<td></td>
<td></td>
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<tr>
<td>☐ Cardiovascular disease</td>
<td></td>
<td></td>
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<tr>
<td>☐ Diabetes</td>
<td></td>
<td></td>
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<tr>
<td>☐ Joint and bone disease</td>
<td></td>
<td></td>
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<tr>
<td>☐ All of the above</td>
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<table>
<thead>
<tr>
<th>Question 27</th>
<th>Multiple Choice</th>
<th>1 points</th>
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</thead>
<tbody>
<tr>
<td>A healthy approach to achieving a healthy body weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Daily exercise.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Increasing fresh vegetable and fruit in the diet.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Avoiding fried foods.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Involving family member in healthy habits.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ All of the above.</td>
<td></td>
<td></td>
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</tbody>
</table>
Question 28  Multiple Choice  1 points
An EKG is used to measure activity of the

- Brain
- Lungs
- Heart
- Stomach

Question 29  Multiple Choice  1 points
Which of the following is not a vital sign:

- Heat rate
- Respiratory rate
- Weight
- Blood pressure
- Temperature

Question 30  Multiple Choice  1 points
When a doctor presses on a person’s abdomen, the doctor is

- Checking if the patient is ticklish.
- Checking if the stomach is full or empty.
- Checking the health of abdominal organs.
- Checking if the patient is overweight.

Question 31  Multiple Choice  1 points
A stethoscope is used to

- Listen to the heart.
- Listen to the lungs.
- Listen to the abdomen.
- Check blood pressure.
- All of the above.
### Question 32  Multiple Choice  1 points
The common cold is caused by

- Germs
- Viruses
- Bacteria
- Cold weather
- All of the above

### Question 33  Multiple Choice  1 points
The most effective way to prevent the spread of viruses and bacteria is

- Hand washing.
- Avoiding sick people.
- Wearing rubber gloves when cleaning.
- All of the above.

### Question 34  Multiple Choice  1 points
Birth control pills are effective at

- Preventing the transmission of syphilis.
- Preventing the transmission of gonorrhea.
- Preventing the transmission of Chlamydia.
- Preventing pregnancy.
- All of the above.

### Question 35  Multiple Choice  1 points
Gonorrhea can be transmitted by

- Unprotected oral sex.
- Unprotected vaginal sex.
- Unprotected anal sex.
- All of the above.
Question 36 Multiple Choice 1 points

Herpes is a sexually transmitted disease caused by

☐ A virus and CAN be cured with medication.
☐ A virus and CANNOT be cured with medication.
☐ A bacteria and CAN be cured with medication.
☐ A bacteria and CANNOT be cured with medication.

Question 37 Multiple Choice 1 points

A cold caused by a virus

☐ Will get better faster if antibiotics are used.
☐ Will get better slower if antibiotics are used.
☐ Should not be treated with antibiotics because they have no effect on viruses.
☐ Should be treated with antibiotics only if the patient is very young or very old.

Question 38 Multiple Choice 1 points

Antibiotics are medications that

☐ Kill viruses
☐ Kill bacteria
☐ Kill both viruses and bacteria
☐ Cause the body to form antibodies against bacteria

Question 39 Multiple Choice 1 points

The rectal exam is used to

☐ To examine the prostate.
☐ Check for colon cancer.
☐ Check for bleeding in the gastrointestinal system.
☐ All of the above.
### Question 40  Multiple Choice
Which of the following is NOT true about antibiotic resistant bacteria

- [ ] They are new species of bacteria that are being discovered for the first time.
- [ ] They are common bacteria that have become immune to antibiotics.
- [ ] They are capable of causing death.
- [ ] They are commonly found in hospitals.

### Question 41  Multiple Choice
Which of the following is the cause of drug resistant bacteria

- [ ] Improper use of antibiotics.
- [ ] Travel to foreign countries without the appropriate vaccinations.
- [ ] The discovery of mad cow disease.
- [ ] The spread of bird flu from China.

### Question 42  Multiple Choice
Which of the following is NOT true about cancer

- [ ] Cancer is an abnormal growth of the body’s cells.
- [ ] Cancer can spread from one part of the body to another.
- [ ] Cancer can recur after being removed.
- [ ] Cancer is less likely to recur in patients who are given antibiotics.
Appendix B

Study Curriculum Lesson Plans
Lab 1: Surface Anatomy and the Physical Exam

Objectives:
- Students will appreciate the location of important surface landmarks on the human body and the organs that are beneath them.
- Students will be introduced to common diseases that affect the organs discussed.
- Students will understand the utility of common physical exam techniques.

Vocabulary:
- **Auscultate**: to examine a body part by listening with a stethoscope
- **Palpate**: to examine a body part using one’s hands
- **Percuss**: to examine a body part by tapping
- **Wheeze**: an abnormal lung sound often heard with asthma
- **Murmur**: an ‘extra’ heart sound that may be normal or may be a sign of a structural heart abnormality (eg, valvular disease)

Organs to be discussed:
- Heart
- Stomach
- Lungs
- Small intestine
- Liver
- Large intestine
- Gall bladder
- Appendix
- Spleen

Diseases to be introduced (by organ):
- Heart
  - **Heart attack**
- Lungs
  - **Asthma**
- Spleen
  - **Sickle cell disease**
  - **Mononucleosis**
- Liver
  - **Cirrhosis**
- Gall bladder
  - **Gall Stones**
- Appendix
  - **Appendicitis**
I. The Physical Exam

Overview:
Elicit from students what they conceive the physical exam to be. After probing their knowledge of the physical exam, guide their thinking toward the exam being an opportunity for physicians to gather information about internal organs from outside the body. A successful physical exam requires that physicians know where the organs are in the body and on what parts of the body they are nearest the surface.

Using the abdominal exam as an example, elicit from students the four major modes of examination: direct observation (looking for symmetry, hernias), palpation (looking for tenderness, abnormal masses), percussion (looking for abnormal amounts of air, fluid or masses) and auscultation (listening for normal/abnormal bowel sounds). Ensure that students have an accurate working definition of these terms as you will use them throughout the course. Reinforce the concept of palpation, percussion and auscultation asking students how other organ systems are examined e.g., vascular system, respiratory system.

Once you have introduced students to the goals and terminology of the physical exam, move on to the thorax. Specific physical exam findings should be discussed later in the context of anatomy (e.g., discuss wheezing when working through the thorax).

Possible discussion questions:

Ask:
What is a physical exam?
Assess student’s understanding of the exam
Why do physician perform a physical exam:
Information gathering in a well patient or a sick patient
What do physicians use to conduct a physical exam—think about how a physician would examine a patient’s abdomen.
Elicit from students that doctors ‘look’, ‘listen’, ‘press’ and ‘tap’.
Introduce the terms observe, auscultate, palpate and percuss.
How does a physician examine the lungs?
Elicit from students that variations of the four examination techniques are found in the examination of every organ system.

II. The Thorax

Overview:
In reviewing the thorax, emphasis should be placed on understanding the ‘rib cage’; namely its structure (vertebrae, ribs, sternum and cartilage) and its function (respiration, protecting thoracic contents). Invite students to palpate ribs and sternum.

After reviewing the rib cage, guide students in identifying the location of the heart and lungs. Demonstrate percussion of the lungs anteriorly and describe how percussion of the
chest is used in the physical exam. Invite students to percuss the chest and challenge them to differentiate between dull and tympanic. Discuss auscultation of the heart and lungs. Elicit from students why the heart is best auscultated from the front.

While discussing auscultation and percussion of the heart and lungs, elicit from students what physicians are looking for when they use these tools. Use asthma as an example in discussing auscultation of the lung. Ask students what one might hear when listening to a patient having an asthma attack (wheezing).

Many of these concepts students may either already know, or can easily deduce. Their thinking should be stimulated with questions. Try to elicit the participation of all your students.

Possible discussion questions by topic:

Rib cage
Ask:

What is the rib cage?

*As an introduction to defining its components*

What does the rib cage do for us? Think about how it may help you if you were in a car accident.

*As an introduction to its protective function*

What happens to the rib cage when you breathe?

*As an introduction to its respiratory function*

Lungs:
Ask:

Where do physicians auscultate the lungs?

*Help students appreciate that we attempt to examine organs at places where they are nearest the surface.*

Why do physicians auscultate the lungs?

*Introduce the concept of listening to breath sounds to assess the function of the lung, i.e., is air freely moving in and out of the lung?*

What might a physician hear when auscultating the lungs of a person having an asthma attack?

*Discuss wheezing as the sound that air makes when it passes through an narrow airway.*

Why do physicians percuss the lungs?

*Reinforce that percussion aims to distinguish between air, fluid and solid mass. In this case, air is normal whereas fluid and/or mass is not. Attempt to demonstrate dull vs tympanic sounds on the cadaver. Invite students to try percussion.*
Heart:

Ask:
Where is the heart located?
*Outline the borders of the heart on the cadaver. Use the illustration to demonstrate why a heart beat is more easily palpated on the left side of the chest.*

Why do physicians auscultate the heart?
*Elicit answers from several students, with the goal of getting at heart rate/rhythm as well as heart function. Touch upon murmurs as a common finding on auscultation—80% of children will, at some point, have a benign murmur and most will ‘out grow’ it. Introduce the concept that murmurs are a sound made by blood moving past a heart valve. The spot on the chest where the murmur is heard and the quality of the sound determine whether it is normal or abnormal.*

Can you percuss the heart?
*Challenge students to explain why the answer is yes, elicit from them that the juxtaposition of a fluid filled organ with an air filled organ allows a physician to ‘percuss out’ the border of the heart.*

Can you palpate the heart?
*While the heart cannot be palpated as directly as a lymph node, palpating the ‘heart beat’ is an important part of the exam—with attention to where the examiner feels the heart beat the strongest as well as the quality of the impulse.*

Can a physician diagnose a heart attack by listening to the heart?
*Introduce the idea that the physical exam is one part of what physicians do. While in a few types of heart attack, new murmurs may develop, there are often no abnormal findings when auscultating the heart of a patient having a heart attack—the diagnosis is made by talking to the patient to detect characteristic symptoms (e.g., left sided chest pain, left shoulder pain), other findings such as sweating, and abnormal EKG.*

III. Abdomen

Overview:
Use the abdominal exam to structure your approach to the abdomen, discussing each organ, its location in the abdomen, and its examination in a stepwise fashion. Starting from the top, mention that the diaphragm is the dividing line between the thorax and the abdomen. As the diaphragm moves up and down with respiration, so does the boundary between the thorax and abdomen. This creates a diagnostic challenge when evaluating injuries (e.g., gunshot and stab wounds) near the diaphragm as the damage may include either or both the abdomen and thorax.

Elicit from students where they perceive the liver to be located as well as its function. Students should know that the liver produces bile, helps to clear toxins (e.g., alcohol), and stores a short-term supply of glucose. Demonstrate on the cadaver, the location of
the liver and how percussion is used to measure its span. Elicit from the students why percussion can be used to ‘percuss out’ the border of the liver. Demonstrate that the liver, under normal circumstances, is ‘protected’ for the most part, by the right rib cage. Have the students explain why, despite its location, the liver can be palpated upon deep inspiration.

Mention the gall bladder briefly, and elicit that it stores bile for release during meals. Given its location, the gall bladder cannot be palpated unless it is enlarged which usually only occurs when its outlet is blocked by a stone.

Elicit from students the location and function of the spleen. Students should know that the spleen functions to filter old red blood cells from circulation and begin the process of recycling hemoglobin. In addition, the spleen is one of several warehouses for white blood cells. As with any filter, the spleen can become clogged and therefore enlarged. Elicit from students that sickle cell anemia is one disease where abnormally shaped red blood cells clog the spleen and cause it to become enlarged. ‘Mono’ also causes the spleen to become enlarged, but in this case, it is white blood cells that are involved not red blood cells. Given its location, students should appreciate that a spleen can only be felt on palpation when it is enlarged.

Ask the group to come to a consensus about where the stomach is and have a student outline its location on the cadaver. Outline on the cadaver the location of the stomach, small intestine and large intestine. The details of the digestive system will be covered later in a separate lab. Students should know that the stomach secretes acid, churns food and slowly releases it to the small intestine. They should know that absorption of nutrients occurs in the small intestine and that water resorption occurs in the large intestine.

Possible discussion questions:

Diaphragm

Ask:

How do we breathe? 

Elicit that inspiration is an active process involving muscle contraction, most importantly the contraction of the diaphragm.Expiration is largely a passive process.

Where is the diaphragm? 

Introduce the diaphragm as the boundary between the thorax and the abdomen.

Liver/Gallbladder

Ask:

Where is the liver?
What is the liver’s function?

*Students should know that the liver processes toxins (e.g., alcohol), produces bile, and stores a short-term supply of glucose as glycogen. In the context of the liver’s function to process toxins, introduce alcoholic cirrhosis a liver disease that results from repeated exposure to a toxin (alcohol). Students should appreciate that while the liver is capable of clearing toxins, it is not impervious to damage from the toxins it handles.*

Why would a physician percuss the liver?

*Introduce the idea that by percussing the liver, physicians can estimate its size which is a marker of liver health.*

Where is the gall bladder?

*Students should know that the gall bladder is a reservoir for bile produced by the liver. The gall bladder releases bile into the digestive tract during meals.*

What is the gallbladder’s function?

Why can’t the gallbladder be palpated?

*Students should appreciate that the gallbladder’s anatomical location prevents palpation except in the case of enlargement.*

Spleen

Ask:

Where is the spleen?

*Students should appreciate it’s rather posterior location relative to the front of the abdomen and that being behind ribs precludes its palpation under normal circumstances.*

What is the function of the spleen?

*Students should know that the spleen filters out old red blood cells and is one of the body’s reservoirs of white blood cells.*

Why would a physician attempt to palpate the spleen?

*Students should appreciate that the spleen will be felt on palpation only when it is enlarged. An enlarged spleen is a hint that there may be a disease that is affecting the spleen e.g., mono or sickle cell disease (early).*

Stomach/small intestine/large intestine

Ask:

Where are the stomach, small intestine and large intestine?

What information does a physician obtain in auscultating the abdomen?

*Elicit from students that bowel sounds arise from peristalsis. Under normal circumstances, the GI systems is continuously peristalsing. In auscultating the abdomen, one of the goals is to assess the degree to which the GI system working i.e. is the GI system peristalsing or not, and what is the quality of the sounds the GI system is making.*
Can the stomach, small intestine and large intestine be distinguished by palpation?

Using their own experience, students should agree that the abdomen is soft, and that without using landmarks, the three are not clearly distinguishable under normal circumstances. Clearly palpable abdominal organs suggests a problem (eg a palpable large intestine suggests constipation).

Where is the appendix?

Students may not appreciate that the appendix is part of the digestive system— or specifically the proximal colon.

What is appendicitis?

Demonstrate McBurney’s point on the cadaver and its significance to the physical exam when screening for appendicitis. Challenge the students to explain why McBurney’s point is the ideal place to examine the appendix—they should now appreciate that McBurney’s point is the place where the appendix is nearest the surface anteriorly, making it the ideal place of examination.
Lab 2: Cardiovascular Disease and the Cardiovascular Exam

Objectives:
- Students will appreciate the structure and function of the cardiovascular system.
- Students will be introduced to common diseases that affect the cardiovascular system, particularly heart disease and peripheral vascular disease.
- Students will be able to identify behaviors that modify the risk of cardiovascular disease.
- Students will understand the elements of the cardiovascular exam.

<table>
<thead>
<tr>
<th>Organs to be discussed:</th>
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<tbody>
<tr>
<td>Atria</td>
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<td>Carotids</td>
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<td>Ventricles</td>
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<td>Valves</td>
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<td>Aorta</td>
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<td>Radial artery</td>
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<tr>
<td>Coronaries</td>
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<td>Dorsalis pedis</td>
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<td>Pulm Art/ Vein artery</td>
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</tbody>
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Vocabulary:

**Atherosclerosis:** a process by which arteries become narrowed by lipid containing plaque

**Plaque:** a deposit of lipid within the wall of arteries

**Ischemia:** a decrease in blood flow to an organ due to a blocked artery

**Hypertension:** high blood pressure

**Cholesterol:** a substance produced by the body and found in a normal diet. Cholesterol is a building block for hormones such as testosterone and estrogen. When found in elevated levels in the blood, cholesterol can contribute to atherosclerosis.

**LDL:** (low density lipid) ‘bad cholesterol’

**HDL:** (high density lipid) ‘good cholesterol’

**Coronary bypass:** surgery that uses a patient’s vein to bypass a blockage of a coronary artery.

**Balloon angioplasty:** a procedure that opens a narrowed coronary artery using an inflatable balloon that is inserted into the artery, inflated, deflated and then removed.

Diseases:

- Coronary artery disease
- Peripheral vascular disease
- Heart attack
- Stroke
- Diabetes

Behaviors to be addressed:

- Smoking
- Drinking
- Exercise
- Diet
- Drug abuse
Introductory remarks:

The most important objective of this lab is for students to understand common cardiovascular diseases in the context of predisposing behaviors. Students should be challenged to assess their own behavior to identify elements that promote or undermine their cardiovascular health. Students should be able to identify changes that can be made to improve their behavior.

The anatomy lab offers a rare opportunity to explore the physical manifestations of disease and make the appropriate associations with predisposing behaviors. The use of the cadavers in this lab is focused around cardiovascular disease. While you may begin the session using your team’s cadaver, you may want to visit other tables to better demonstrate the anatomy of specific cardiovascular diseases.

In the process of exploring a disease, you will have an opportunity to explain the anatomy of the organ(s) affected. In this lab you will focus on heart attack, stroke and peripheral vascular disease, allowing you to teach the anatomy of the heart, circulation to the brain and circulation to major body parts and organ systems.

I. Heart Attack

Overview:
Elicit from students what they believe a heart attack to be. Students should understand that a heart attack is the result of reduced blood flow to heart muscle. The most common cause of myocardial ischemia is coronary artery occlusion with plaque. Students should understand that plaque formation does not happen acutely (days and months) but develops over a period of years in response to elevated serum lipid and cholesterol levels. Fatty streaks, the precursors to atherosclerotic plaques have been observed in “healthy” twenty year olds. Students should appreciate that early and consistent behavior modification is the best way to reduce one’s risk of a heart attack.

Help students develop a more accurate understanding of chest pain. Students should understand that chest pain is always taken seriously because one of its causes, heart attack, is a medical emergency. However, there are many common and comparatively benign causes of chest pain that are worthy of mention (especially since chest pain in an adolescent is more likely to be non-cardiac). Elicit from students, what they perceive chest pain to be. Ask students whether chest pain can be caused by things other than a heart attack. Discuss some of the common causes of chest pain with students. Gastro-esophageal reflux disease (heart burn) is a common cause of chest pain. Elicit from students what they understand heart burn to be. Unfortunately, this misnomer often leads people to believe that heart burn has a cardiac origin. Musculoskeletal problems are another common cause of chest pain. Strain of the pectoralis muscles are a common cause of chest pain. Intercostal muscle spasm is another cause of localized chest pain. Students should appreciate that physicians use the physical exam and adjunctive tests to stratify chest pain into high and low risk categories.

Students should appreciate the symptoms of a heart attack and the appropriate response. People having a heart attack often experience “crushing” chest pain that is worse with exercise, they are often short of breath, they are often found sweating, they sometimes complain of shoulder, arm or jaw pain and they are usually anxious. Students should know that sudden chest pain should be taken seriously and being overly cautious is never a bad thing given the potential for death if presentation to the ED is delayed. People with sudden chest pain should be taken to the ER immediately. If at any time the person looses consciousness, is having trouble breathing or seems “out of it” 911 and ambulance transport is the best option.
Possible discussion questions:

Ask:

What is a heart attack?

_Students should appreciate that a heart attack is caused by decreased blood flow to the heart._

What causes a heart attack?

_Students should appreciate that there are several factors that predispose patients to heart attack. The most common etiology is a plaque that occludes a coronary artery. Diet, exercise and smoking are the three most important modifiable behaviors that determine heart attack risk. Coronary vasospasm due to cocaine use can also cause heart hypoperfusion—a speculated diagnosis in the recent death of rapper, Old Dirty Bastard._

Who gets a heart attack?

_Most often, patients who suffer from heart attack are older than 45. They usually suffer from coronary artery disease precipitated by years of poor diet, smoking and lack of exercise. Patients with uncontrolled diabetes also make up a significant proportion of patients with heart attack. Occasionally, young people with a history of cocaine use die of heart attack due to cocaine induced coronary vasospasm._

When is the best time to begin to prevent a heart attack?

_Fatty streaks, the precursor to plaques begin to form during the second decade. Therefore, heart attack prophylaxis should begin during adolescence. Currently, the most effective method of preventing a first heart attack is proper diet and exercise, smoking cessation and for diabetics, tight glucose control. The major obstacle to improving diet and exercise among Americans is the lack of immediately perceivable benefits along with a culture that is inherently heart unfriendly._

Show:

- Diseased coronary arteries
- Demonstrate the vascular supply to the heart
- Demonstrate the chambers of the heart
- Track the flow of blood from the vena cava to the aorta. Ensure that students understand that blood in the vena cava is being returned from the body rich in CO2 and depleted of oxygen. Ensure students understand that blood in the aorta is bound for the bodies tissues and organs and is rich in oxygen and depleted of CO2

II. Stroke

Overview:
_Students should understand what a stroke is and appreciate how in certain respects, stroke is very similar to a heart attack. In both cases, vascular supply is compromised resulting in damage to the organ—the heart in the case of a heart attack, and the brain in the case of a stroke. Because plaque formation is one of the major etiologies of stroke, it is understandable that the risk factors for stroke are similar: poor diet, sedentary lifestyle, smoking, uncontrolled hypertension and uncontrolled diabetes._
Students should appreciate that the internal carotid and the vertebral arteries provide blood flow to the brain and are the brain’s equivalent to the heart’s coronaries. Just as plaques can be demonstrated in the coronaries of cadavers that had a high likelihood of heart attack, plaque can also be demonstrated in the carotids of cadavers that had a high likelihood of stroke. When showing students plaques in the carotid, challenge them to explain why carotid plaque occur most frequently at the bifurcation of the carotid.

Students should appreciate the signs of stroke and the appropriate response. People with stroke usually have a unilateral deficit corresponding to the area of the brain that is hypoperfused. Unilateral muscle weakness or paralysis are common—affecting the entire side of the body or just part. Speech disturbances or facial droop are another easily recognized sign. These signs warrant immediate transport to the ED. If the person is unresponsive or is debilitated by weakness, 911 and ambulance transport are the best option.

Ask:

What is a stroke?
*Students should understand that a stroke is the result of compromised blood flow to the brain. Whereas vascular compromise to the heart results in chest pain, vascular deficits to the brain result in loss of function related to the area of the brain affected: paralysis when motor areas are affected, dysarthrias when speech areas are affected etc. A common mechanism for vascular compromise in stroke is cerebral artery occlusion with a plaque fragment that became dislodged from the carotid.*

Who gets a stroke?
*While vascular disease begins to develop while we are young, people do not succumb to it until they are older. Stroke typically affects people over fifty. Quite often, there are risk factors in their history that predisposed them to stroke: smoking, poor diet, uncontrolled hypertension, uncontrolled diabetes etc.*

When is the best time to try to prevent a stroke?
*Stroke prevention is largely a lifestyle that should begin early when people are young. The key is an active lifestyle along with a proper diet and no smoking.*

Why are plaques more likely to form at bifurcations?
*Turbulent flow is a key component to plaque formation at bifurcations. It is believed that sheer forces caused by turbulent flow cause damage to the endothelial wall. Dysfunctional healing with deposition of lipid occurs in people with elevated serum lipid profiles.*

Why don’t plaques form in veins?
*The venous system is a low-flow, low-pressure system and is not capable of generating the sheer forces needed to potentiate damage and dysfunctional healing. Low flow, however, creates another problem: thrombosis. Stagnating blood has a higher propensity toward clotting than flowing blood. Therefore, venous clots are more common than arterial clots. Students should appreciate that clots that form in the venous system can become dislodged. They should understand that dislodged venous clots get trapped in the capillary bed of the lungs. If it weren’t for the lungs, venous clots would have access to the arterial system and become lodged in any organ (this does happen on occasion in patients that have a patent foramen ovale).*

Show:
- The carotids: internal and external. Highlight the importance of the internal carotid in providing blood flow to the brain.
• Show the bifurcation of the carotid and highlight the significance of bifurcations in the development of plaque.
• Show the vertebral arteries as they come off of the subclavian arteries and explain their importance in brain perfusion

III. Peripheral vascular disease
Overview:
Peripheral vascular disease is a common diagnosis in individuals with atherosclerotic disease, yet it is largely underappreciated by lay people, likely overshadowed by more ominous sequelae of atherosclerotic disease such as heart attack and stroke. By this point in the lab, students should begin to appreciate that any vessel can be affected by atherosclerotic disease. The symptoms of peripheral vascular disease can be predicted by hypothesizing what would happen if blood supply to a particular organ is compromised. Again, the risk factors are the same: poor diet, lack of exercise, smoking, hypertension and uncontrolled diabetes.

Challenge students to predict the symptoms of a person with peripheral vascular disease involving the femoral artery. Reduced blood flow to the leg would result in decreased exercise tolerance. A person would probably perceive this as cramping pain on mild exertion. The leg may also be cool to the touch due to reduced perfusion. It should appear somewhat blanched. You would expect pulses distal to the stenosed vessel to be reduced: in this case, diminished popliteal, dorsal pedis and posterior tibial pulses.

Ask:

Why do physicians check pulses?
Students should understand that there is more to checking pulses than assessing heart rate. Briefly introduce students to the pulse exam. Students should appreciate that in patients where vascular disease is suspected, physicians check pulses in every limb to determine whether blood is flowing. A diminished pulse suggests diminished blood flow. Show students where the pulses can be palpated and invite students to palpate their own pulses: carotid, radial, femoral, dorsal pedis and posterior tibial.

What symptoms would you expect a person to have if their femoral artery became partially blocked with plaque?
Students should appreciate that reduced blood flow reduces the function of an organ. If the organ is a muscle, (eg the heart or the soleus) they become fatigued at a lower exertion threshold. Also, in the case of muscles, patients experience the classic symptoms of fatigue (cramping with regard to skeletal muscle, and chest pain with regard to cardiac muscle). Ask students how they expect skin color and temperature to change in this scenario. Students should be able to agree that skin will appear blanched and temperature will decrese.

What would you expect to find on pulse exam if the patient has compromised blood flow in the femoral artery?
As you review the areas to palpate pulses on the lower extremity, students should be able to predict that an upstream occlusion will result in decreased pulses downstream. The quality of the femoral pulse may be normal or abnormal depending on the location of the occlusion relative to the palpation point, but a bruit should be audible on auscultation. One would expect pulses distal to the femoral artery to be diminished on the affected side.

Where is blood pressure measured?
Students should know that the brachial artery is the standard for measuring blood pressure.

What is blood pressure?
Students should appreciate that blood pressure is the pressure that blood exerts on the walls of arteries. Students should know that the arterial side is the high pressure side of the vascular system compared to the venous side. Students should understand that a blood pressure measurement consists of two numbers. The pressure within our arteries is pulsatile. The “upper” number corresponds to the pressure during ventricular contraction, and the “lower” number corresponds to the pressure during ventricular relaxation.

Why are physicians interested in blood pressure?
Students should understand that pressure within the arterial system is mandatory for blood to reach organs. At the same time, too much pressure increases the rate at which the vascular system becomes damaged and accelerates the development of plaques. High blood pressure can directly damage sensitive organs such as the kidney and in extreme cases, the brain. Because patients usually have no symptoms when their blood pressure is high, physicians routinely check blood pressure to “catch” high blood pressure before it causes serious harm.

Show:
Descending aorta
Subclavian and brachial arteries. Mention that blood pressure is measured through the brachial artery.
Iliac and femoral arteries
Areas for pulse palpation

IV. Risk factors and risk behaviors
Overview:
By this point in the lab, students should be proficient at identifying risk factors for cardiovascular disease. In this section, take a few moments to explain how each risk factor or risk behavior contributes to the development of cardiovascular disease.

Students should understand that cholesterol is a naturally occurring substance. It is found in our diet and it is produced by our bodies. Students should appreciate that cholesterol is the building block for several hormones, among them testosterone and estrogen. Cholesterol is an integral part of cell membranes. Cholesterol only becomes a problem when it is found in abnormally high levels in the body. In this circumstance, cholesterol becomes deposited within arteries as plaque. As plaques enlarge, they obstruct the vessel and reduce blood flow to an organ.

In addition to cholesterol, low-density lipoprotein (LDL) and high-density lipoprotein (HDL) levels have been correlated with propensity toward plaque formation. Students should be familiar with LDL and HDL as serum levels of these lipoproteins are routinely measured to screen patients for elevated risk of cardiovascular disease. Students should understand that LDL and HDL are involved in cholesterol transport. In most basic terms, LDL delivers cholesterol to body cells and tissues whereas HDL scavenges cholesterol from the body and transports it toward the liver where it is metabolized. Thus, high serum HDL levels coupled with low LDL levels are protective against cardiovascular disease whereas low HDL and high LDL increases risk of cardiovascular disease.

Diet and exercise play an important role in ones cholesterol and lipoprotein profile. Intuitively, a diet rich in fats will favor the delivery of cholesterol to body cells for storage. Since the blood stream is the means of transporting cholesterol, increased cholesterol transport means increased amounts of cholesterol in the blood and more opportunities for cholesterol deposition within vessel walls. LDL
levels increase and HDL levels decrease, reflecting the cholesterol transport balance. Exercise stimulates the metabolism of fats and favors the transport of fats toward the liver to be metabolized to generate energy.

Students should appreciate what a healthy diet entails:

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Daily allowance</th>
</tr>
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<tbody>
<tr>
<td>Total fat</td>
<td>less than 65 g</td>
</tr>
<tr>
<td>Carbs</td>
<td>about 300g</td>
</tr>
<tr>
<td>Fiber</td>
<td>at least 25 g</td>
</tr>
<tr>
<td>Protein</td>
<td>about 53g</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>less than 300 mg</td>
</tr>
</tbody>
</table>

As a reference, one meal consisting of a Quarter Pounder with cheese (29 g fat) and an order of large fries (26 g fat) at McDonalds easily provides 85% of a person’s daily allowance of fat.

Students should understand that smoking and poorly controlled diabetes both increase a persons risk of developing cardiovascular disease. Smoking and uncontrolled diabetes promote vascular damage leading to inflammation and resultant plaque formation. The mechanism of smoking related endothelial damage is multifactorial and beyond our scope, but involves changes in blood viscosity, circulating toxins and a propensity toward hypertension—all three, facilitators of vascular injury. Chronic hyperglycemia results in glycosylation of endothelial proteins that stimulates an inflammatory response. This inflammatory response promotes diffuse atherosclerotic disease.

Engage your students in a discussion of risk factors for cardiovascular disease. Focus on diet, exercise, smoking and diabetes. Probe their understanding of what cholesterol, LDL and HDL are. Help them appreciate the role of these substances in protecting or promoting cardiovascular disease. Beyond knowing what behaviors increase risk of cardiovascular disease, challenge your students to understand how these behaviors contribute to disease.

V. Modifying risk behavior
Overview:
The most difficult task in addressing cardiovascular disease, is promoting a healthy lifestyle in a culture that has grown accustomed to foods that are high in fats and sugars, and low in fiber. Socioeconomics often compounds the problem by limiting access to quality fresh vegetables and minimally processed foods. Success will likely require a multidisciplinary approach and cooperation between parents, schools, health care providers and local and federal government agencies.

The students should be working on food diaries to help them appreciate what a healthy diet is. Talk to students about what they’ve discovered about their own diets. How close are they to a balanced diet? What are their ideas regarding realistic changes that they can make to their diet to improve their health?
Lab 3: Energy Management in the Human Body

Objectives:
- Students will understand that food is the body’s energy source, measured in calories.
- Students will understand that maintaining body weight requires a balance between calories consumed and calories spent.
- Students will understand that the body’s Total Energy Expenditure is comprised of Resting Metabolic Rate, Thermic Effect of Feeding and the Thermic Effect of Physical Activity.
- Students will understand the role that the liver, muscle and adipose play in energy storage and usage.
- The relationship between healthy diet and exercise and cardiovascular risk reduction will be reviewed.

Vocabulary:

Food calorie: unit of energy equivalent to 1 kilocalorie. Defined as the amount of energy required to raise the temperature of 1 liter of water by one degree Celsius.

Resting Metabolic Rate: the number of calories the body uses passively ie to maintain body temp, conduct ventilation, pump blood etc.

Thermic Effect of Feeding: the calories spent to digest food.

Thermic Effect of Activity: calories spent doing voluntary activities, eg walking, running, fidgeting.

Total Energy Expenditure: the total number of calories spent each day ie the sum of Resting Metabolic Rate, Thermic Effect of Feeding, and Thermic Effect of Activity.

Aerobic respiration: the body’s preferred method of generating energy. By using oxygen, food yields more ATP per gram of substrate. Furthermore, aerobic respiration does not result in fatigue.

Anaerobic respiration: less efficient method of energy generation when oxygen supplies are limited. Results in fatigue due to lactic acid accumulation.

Organs to be discussed:
- Liver
- Adipose
- Muscle

Diseases:
- Coronary artery disease
- Peripheral vascular disease
- Heart attack
- Stroke
- Diabetes

Behaviors to be addressed:
- Types of aerobic exercise
- Goal of exercise
- Walking vs Running
- Sports
- Inactivity
- High fat vs low fat diet
- High calorie vs low calorie diet
Overview:

The purpose of this lab is to help students understand that the balance between the calories we consume and the calories we expend determines whether our weight changes or remains stable. By the end of the session, students should understand that several factors affect our body weight including age, level of physical activity, genetics and diet.

I. Metabolism

Students should understand that metabolism is the sum of all reactions that happen in the body. These reactions can be categorized as anabolic or catabolic. Anabolic reactions generate macromolecules from simpler precursors, and generally are endothermic. Catabolic reactions convert larger molecules to smaller ones. Many catabolic reactions can be exothermic (such as the catabolism of ATP), but not all.

II. Respiration and ATP

Students should understand that ATP is the fuel that cells use to do work. The energy in ATP is found in phosphate bonds. Once an ATP’s energy is spent to do work, it is recharged using energy from food that we have eaten. The energy found in bonds between atoms in fats and carbs are released during respiration and is used to reform the phosphate bonds of ATP. Students should understand that during respiration ATP is not produced de novo from carbs and fats, a common misconception among students. Instead, ADP and AMP (spent ATP) are recharged by reforming bonds with phosphate. Students should feel comfortable contrasting aerobic respiration with anaerobic respiration.

III. The liver as a storage area for glucose

Revisit the liver during this lab. Students should appreciate its location and its relationship to the digestive tract. Review the functions of the liver, with focus on the liver as the largest reserve of glycogen. Students should understand that excess carb is preferably stored as glycogen because converting glucose to fat requires a very large energy investment. Unlike storing excess fats, our capacity to store excess carb as glycogen is relatively finite. The average individual can store around 2000 calories in the form of glycogen—enough to support life for one day. Students should appreciate that glycogen is body’s preferred source of energy between meals, during fasting and at the beginning of a workout.

IV. Adipose as a storage area for fats

Compare the fat distribution among different cadavers. A healthy young man stores about 100,000 calories in fat. Compare this with the 2,000 calories that one can store in glycogen. An obese person can store several hundred thousand calories in fat. Encourage students to identify areas in the body where fat is distributed more heavily. Encourage students to identify a pattern in fat distribution among men and women.

Students should understand that excess fats are stored in specialized fat cells distributed throughout the body. When a person gains weight, the number of fat cells in their body does not increase; instead, the fat cells increase in size to accommodate more fat. To some extent, it is true that, where a person’s overweight is distributed affects how difficult it is to lose. Truncal weight is somewhat easier to loose than girdle weight. This is because of a differential distribution of receptors on the surface of fat cells depending on their location. The receptors on each fat cell set the threshold for retaining and releasing lipid.
V. Muscle
Compare muscle mass among cadavers. Muscle mass is related to the amount of work that a muscle has to do. People who were bedridden by illness before death have decreased muscle mass due to a decreased work load on muscles. People who were able to remain active before death tend to have more muscle mass. The obese often have more muscle mass than a slim individual because the increased work of moving about hypertrophies their muscles.

VI. Exercise
Students should understand the importance of exercise. Admittedly, the health benefits of exercise are not always enough to motivate a person to include exercise in their daily routine. The ill health effects of not exercising are so far off for young people that the importance of exercise is underappreciated. Students should be reminded that exercise should be fun. Furthermore, there are many creative ways to include exercise into your routine. For some, exercising is getting off a bus a couple of stops early and walking the rest. Others play sports, use a gym, run, dance etc. A healthy aerobic workout should be comfortable and sustain the persons heart rate at 60% of maximum for 30 minutes. Predicted max heart rate can be estimated using the formula 220 - age.

Students should understand the difference between aerobic and anaerobic exercise. Aerobic exercise gets more attention because it has a greater impact on improving health.
Lab 4: Infectious Disease

Objectives:

- Students will appreciate that infectious disease is caused by foreign organisms (bacteria, fungi, parasites) or viruses
- Students will understand the role that behavior plays in preventing infection (eg hand washing, proper food preparation, “safe” sexual behavior)
- Students will understand the strategies that the body uses to prevent infection; or eliminate infection if there has been a breach in the body’s defenses.
- Students will appreciate that the mainstay of pharmacologic prevention of infectious disease is vaccination.
- Students will understand that pharmacologic treatment of infection depends on whether the infection is viral, bacterial, fungal or parasitic.
- Students will understand that antibiotics treat cellular infections
- Students will appreciate that viruses are particularly difficult to treat because they are not cellular—in fact one could argue that they are not living. Therefore, antibiotics have no effect.

Vocabulary:

*Virus:* an intracellular parasite containing a core with either DNA or RNA covered by a protein coat. Viruses are not capable of reproducing on their own. They rely upon the cells they infect for reproduction

*Parasites:* this category includes protozoa (single celled parasites such as malaria) and multicellular helminthes (worms such as tape worm)

*Antibiotic:* a drug that has the ability to weaken or kill foreign cellular invaders

*Antiviral:* a drug that has either interrupts viral replication or magnifies the body’s response to viral invasion

*Vaccine:* a substance that induces the host to develop temporary or lifelong immunity to a specific infectious disease.

*Immune system:* a complex system of cells and proteins that defends the body against infection.

*Antibody:* a protein produced by B cells that attaches to foreign invaders and marks them for destruction by macrophages

*B cell:* Produce antibodies

*T cell:* these cells recognize foreign material, especially virus infected cells. T cells respond by destroying infected cells.

Organs to be discussed:

- Lymph nodes
- Spleen
- Bone Marrow
- Blood

Diseases:

- Tuberculosis
- Common Cold
- Strep throat
- Influenza
- HIV
- Hepatitis A, B, E
- Syphilis, Chlamydia, Gonorrhea

Behaviors to be addressed:

- Hand washing
- Proper food preparation
- “Safe” sexual behavior
- Timely visits to a physician when symptomatic
- Regular screening for sexually active individuals
Overview:

The purpose of this lab is for students to understand the relationship between the infectious pathogens in the world around us and our bodies’ defenses to keep them at bay. Successful resistance to infectious disease is the result of several overlapping defenses. Students should appreciate that the integrity of our behavior, skin, and immune system; along with the virulence of the pathogen, determine our susceptibility to infection.

Students should appreciate that bacteria, viruses, fungi; and to a lesser extent parasites, are all around us. Students should appreciate that it is quite normal, and actually health promoting to be colonized by certain bacteria. Our skin, mucous membranes and our immune systems allow us to balance the benefits of colonization with the cost of infection. Age, immunocompetence of the host, and the presence of other infections affect our ability to maintain the boundary between colonization and infection.

After reviewing the major categories of infectious pathogens (ie, viruses, fungi, bacteria and parasites), take your students through a linear progression of a pathogen from outside to inside the body. Starting outside of the body, review the functions of the skin with emphasis on its role as a barrier that excludes organisms. Demonstrate the many ways in which our external barriers (skin and mucous membranes) can be overcome by a pathogen (see student handout). Now inside the body, explain the mechanisms through which the body fights against an invading pathogen. Review the relevant anatomy with attention to bone marrow, thymus, spleen and lymph nodes.

At the end of the lab, students should be able to describe how we develop immunity to certain pathogens and how the phenomenon of immunity is harnessed by vaccines to confer immunity without infection. While the detailed mechanism of acquiring immunity is not important for students at this level to master, they should understand that the immune response to a new pathogen is slower and less robust than in subsequent exposures. During the initial exposure, the person may become noticeably ill as the immune system attempts to eradicate the pathogen. However, with primary exposure come memory T and B cells which can quickly augment an effective immune response in the event of re-exposure. Having reviewed immunity, probe the students understanding of vaccination and fill in the gaps as needed.

Students should be challenged to explain why certain pathogens are not eradicated by the immune systems and thus necessitating the need for therapy. The answer to this question is complex. In some cases, it is the host’s inability to mount an effective response (due to age, nutrition, pre-existing infections etc) that necessitate therapy. In other cases, it is the adaptations of the pathogen that allows it to attenuate, evade or quell the immune response (eg, Mycobacterium tuberculosis, syphilis, and HIV).

Students should appreciate that the identity of the pathogen, as well as the clinical status of the patient, determine which, if any, treatment is warranted. Students should appreciate the difference between antibiotics and antiviral agents. The spectrum of antiviral agents is very small and are useful in only a limited number of viral infections, among them: hepatitis B, herpes simplex, influenza and HIV. While there is symptomatic treatment available for the common cold, there is no antiviral treatment.
Lab 5: Diagnostic Testing

Objectives:

- Students will appreciate that diagnostic testing is an extension of the history and physical
- Tests are ordered based on the signs and symptoms that the patient presents with
- Certain tests are routinely ordered in healthy patients as part of routine care to screen for common treatable diseases (e.g., cholesterol and glucose screens)
- Students will appreciate the different types of information generated by different testing modalities (e.g., x-ray vs CT).

Vocabulary:

X-ray: imagine modality using electromagnetic radiation to view the contents of the body. X-ray imaging produces a flat two-dimensional representation of the exposed field.

CAT scan: a computer-enhanced x-ray that attempts to recreate the three-dimensional landscape of the body by creating a series of x-ray “slices” as the patient is passed through the scanner.

MRI: similar to CT in that it produces a series of slices. MRI uses a magnetic field to produce the images, sparing the patient exposure to harmful x-rays. MRI produces higher resolution images of exceptional quality especially with soft tissue and CNS. The time and cost to acquire MRI images limits its use when other modalities are sufficient to make the diagnosis.

Mammogram: a specific x-ray protocol to examine breast tissue.

Ultrasound: imagine modality that uses sonic energy to produce a live image of internal structures. A valuable tool when evaluating structures that are in dynamic motion (e.g., heart).

Angiogram: an x-ray protocol that uses dye to visualize blood vessels.

Stress test: this is an exercise tolerance test designed to detect heart disease. While on a treadmill, a patient’s EKG is monitored while performing increasing physical exertion.

Biopsy: evaluation of a suspicious mass by removing a small piece and performing a microscopic evaluation. The minimally invasive biopsy spares the patient a more invasive surgery if the result is negative.

Organs to be discussed:

Multi-system review

Diseases:

- Colon cancer
- Coronary Artery Disease
- Stroke
- STDs
- Diabetes
- Breast cancer
- Aortic Aneurism

Behaviors to be addressed:

Screening tests:
- Colonoscopy
- Mammography
- Stress testing
- PSA
Overview:

The purpose of this lab is to give students a better understanding of common diagnostic investigations that physicians use to evaluate a patient’s health. Students should view diagnostic testing as an extension of the physical exam. In most settings, diagnostic tests are ordered to further describe abnormal findings on history and physical. For example a Complete Blood Count ordered as part of the work-up for a patient complaining of fatigue to rule in or rule out anemia. Other tests are ordered on a routine basis to pick up common diseases that are treatable, but can often be missed on physical exam. For example, regular sigmoidoscopy to screen for colon cancer in healthy adults over fifty.

The session is organized into two parts: diagnostic imagining and laboratory investigation. During the course of the lab, take your students to each of the radiology stations. After cycling through all of the stations, students should be able to discern between the different imaging modalities: x-ray, CT, MRI, angiography and ultrasound. While it is not important for students to understand the physics that make a CT images different from an MRI, it is important for students to understand the why CT is preferred over MRI in certain clinical scenarios and vice versa. The same can be said for the other imagining modalities.

When viewing images with students, adopt a systematic approach. Here is one approach to viewing an image:

- Image quality: anything on the film indicate exposure artifact?
- View (not relevant with our students): eg AP vs PA; supine or standing; coronal, sagittal or axial; with or without contrast etc
- Manmade hardware: any tubes or devices in the patient
- Muscle, connective tissue, nerves
- Bone
- Vessels
- Internal Organs

While cycling through the station, use the opportunity to review major organ systems and the diseases associated with them. This is our final module with the students and this topic lends itself easily to review for their final exam.

Spend some time discussing laboratory investigation. Again, the selection of lab tests is a function of h&p findings as well as regular screening protocols. Discuss the utility of a CBC and Electrolyte panel. Talking points include anemia, infection and electrolyte disturbance—all apparent on CBC/Lytes. Take a moment to explain how HIV screening is performed (see student handout).

Urinalysis is a useful tool to evaluate the genitourinary tract. Remind students of the anatomic relationship of the kidneys, ureters, bladder and urethra. Urine samples can provide information regarding the health of each of these structures. Talking points include urinary tract infection, kidney stones, kidney disease, STDs.

Below are some screening guidelines for healthy asymptomatic patients that you can share with your students:
<table>
<thead>
<tr>
<th>Disease</th>
<th>Test</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colon Cancer</td>
<td>Sigmoidoscopy, Fecal Occult Blood Test, Colonoscopy</td>
<td>In people without family hx of colon ca, screening begins at age 50. Sig every 3-5yrs, FOBT annually, Colonoscopy every 10yrs</td>
</tr>
<tr>
<td>Breast Cancer</td>
<td>Manual Breast Exam Mammography</td>
<td>Monthly breast exam for all adults; mammogram every 2 yrs for women 40-50yrs, annually for women over 50</td>
</tr>
<tr>
<td>Prostate Cancer</td>
<td>Digital Rectal Exam PSA</td>
<td>Controversial. Annual DRE and PSA in men over 50</td>
</tr>
<tr>
<td>Coronary Artery Disease</td>
<td>Fasting lipoprotein profile</td>
<td>Every five years starting at age twenty</td>
</tr>
<tr>
<td>STDs</td>
<td>HIV antibody VDRL (syphilis) Serum Gonococcus and Chlamydia</td>
<td>Controversial. Annually for all patients sexually active</td>
</tr>
</tbody>
</table>
Appendix C

Session Pre/Post Tests
Lab 1: Surface Anatomy and the Physical Exam, Pre/Post Test

Question 1  Matching  7 points

Match the best place to

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
<td>F</td>
</tr>
</tbody>
</table>

- listen to the heart
- listen to the stomach
- listen to the lungs
- take a pulse
- take blood pressure
- feel for an enlarged liver
- feel for swollen nodes (glands)
**Question 2  Matching**

**MATCH**

- **liver** 98H
- **kidney** 99H
- **lungs** 100H
- **stomach** 101H
- **heart** 102H
- **radial artery (pulse point)** 103H
- **brachial artery (blood pressure measurement)**
**Question 3** Matching  5 points

Match the organ with its function

<table>
<thead>
<tr>
<th>Organ</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver</td>
<td>A. &quot;purifies&quot; the blood</td>
</tr>
<tr>
<td>kidney</td>
<td>B. removes dead blood cells</td>
</tr>
<tr>
<td>spleen</td>
<td>C. makes urine</td>
</tr>
<tr>
<td>large intestine</td>
<td>D. digests food</td>
</tr>
<tr>
<td>small intestine</td>
<td>E. absorbs water from the intestinal tract</td>
</tr>
</tbody>
</table>

**Question 4** Matching  4 points

Match the disease and the organ

<table>
<thead>
<tr>
<th>Disease</th>
<th>Organ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mononucleosis (mono)</td>
<td>A. lungs</td>
</tr>
<tr>
<td>asthma</td>
<td>B. liver</td>
</tr>
<tr>
<td>hepatitis</td>
<td>C. spleen</td>
</tr>
<tr>
<td>appendicitis</td>
<td>D. appendix</td>
</tr>
</tbody>
</table>

**Question 5** Multiple Choice  1 points

A doctor might listen for a murmur in the

- [ ] lungs
- [ ] stomach
- [ ] heart
- [ ] ear

**Question 6** Multiple Choice  1 points

Which of the following statements about the ribcage is true:

- [ ] The rib cage remains motionless when we breathe.
- [ ] The rib cage moves upward and outward with inhalation.
- [ ] The rib cage moves upward and outward with exhalation.
- [ ] The rib cage moves upward during inhalation and woutward during exhalation.
Question 7  Matching  4 points
Match the vocabulary word with its correct definition

- Palpate
- Percuss
- Wheeze
- Auscultate

A. To examine by tapping.
B. To examine by pressing.
C. An abnormal lung sound.
D. To examine a body part by listening.

Question 8  Multiple Choice  1 points
Why do physicians listen to the heart from the front and not from the back?

- Because it is more comfortable for the patient.
- Because listening to the heart and the lungs at the same time is confusing.
- Because the heart is closer to the chest than it is to the back.
- Because it is faster to listen to the heart from the chest than it is to listen from the back.

Question 9  Multiple Choice  1 points
You are a physician and a patient comes to your office because she thinks she is having a heart attack. Which of the following techniques will be MOST helpful in deciding whether to send the patient to the hospital?

- Auscultating the heart.
- Palpating the heart.
- An EKG.
- Percussing the heart.
- Checking blood pressure.

Question 10  Matching  6 points
Each of the organs listed on the left is located in the abdomen or thorax. Match the organ with its proper location (abdomen or thorax).

- Heart
- Liver
- Large intestine
- Lungs
- Stomach
- Spleen

A. Thorax
B. Abdomen
<table>
<thead>
<tr>
<th>Question 11</th>
<th>Multiple Choice</th>
<th>1 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>A friend of yours recently had her appendix removed. Where would you expect to find the scar?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐</td>
<td>On the lower right abdomen.</td>
<td></td>
</tr>
<tr>
<td>☐</td>
<td>On the lower left abdomen.</td>
<td></td>
</tr>
<tr>
<td>☐</td>
<td>In the middle, just above the belly button.</td>
<td></td>
</tr>
<tr>
<td>☐</td>
<td>On the upper right abdomen.</td>
<td></td>
</tr>
</tbody>
</table>
Lab 2: Cardiovascular Disease and the Cardiovascular Exam (Pre/Post Test)

Question 1  Ordering  9 points

What is the path that blood takes through the heart? Put the following landmarks in order STARTING with the VENA CAVA.

- Vena cava
- Left ventricle
- Aorta
- Lungs
- Right atrium
- Left atrium
- Pulmonary artery
- Pulmonary vein
- Right ventricle
Question 2  Multiple Choice  1 points

The diagram below shows an artery. Where along the artery is a plaque MOST likely to form?

A  
B  
C  
D

Question 3  Multiple Choice  1 points

Which of the following is TRUE about blood in the Pulmonary Artery?

- Oxygen rich, carbon dioxide poor
- Oxygen rich, carbon dioxide rich
- Oxygen poor, carbon dioxide rich
- Oxygen poor, carbon dioxide poor
<table>
<thead>
<tr>
<th>Question 4</th>
<th>Multiple Choice</th>
<th>1 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which of the following is TRUE of blood in the Pulmonary Vein?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Oxygen rich, carbon dioxide poor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Oxygen rich, carbon dioxide rich</td>
<td></td>
<td></td>
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<tr>
<td>☐ Oxygen poor, carbon dioxide rich</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Oxygen poor, carbon dioxide poor</td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 5</th>
<th>Multiple Choice</th>
<th>1 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which of the following is TRUE about blood in the left ventricle?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Oxygen rich, carbon dioxide poor</td>
<td></td>
<td></td>
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<tr>
<td>☐ Oxygen rich, carbon dioxide rich</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Oxygen poor, carbon dioxide rich</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Oxygen poor, carbon dioxide poor</td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 6</th>
<th>Multiple Choice</th>
<th>1 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Of the following, which is most likely to cause a heart attack in a person less than 25 years old?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Heart disease</td>
<td></td>
<td></td>
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<tr>
<td>☐ Smoking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Heart failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Cocaine</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 7</th>
<th>Multiple Choice</th>
<th>1 points</th>
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</thead>
<tbody>
<tr>
<td>Which of the following do NOT increase a person's risk of stroke?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Poor diet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ High blood pressure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Uncontrolled diabetes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Migrane headaches</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Smoking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 8</td>
<td>Multiple Choice</td>
<td>1 points</td>
</tr>
<tr>
<td>------------</td>
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</tr>
<tr>
<td>Which of the following in NOT a symptom of stroke?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Muscle weakness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Shortness of breath</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Speech disturbance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Vision disturbance</td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 9</th>
<th>Multiple Choice</th>
<th>1 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which of the following in NOT a symptom of heart attack?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Shortness of breath</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Arm pain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Chest pain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Back pain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Lower jaw pain</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 10</th>
<th>Multiple Choice</th>
<th>1 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncontrolled diabetes increases the risk of which disease:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Stroke</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Heart attack</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Peripheral vascular disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ All of the above</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 11</th>
<th>Multiple Choice</th>
<th>1 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>At what age should a person begin thinking about their cardiovascular health and modify their behavior to protect their cardiovascular system?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Age 13-19</td>
<td></td>
<td></td>
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<tr>
<td>☐ Age 20-29</td>
<td></td>
<td></td>
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<tr>
<td>☐ Age 30-39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Age 40-49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Age 50 and above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 12</td>
<td>Multiple Choice</td>
<td>1 points</td>
</tr>
<tr>
<td>-------------</td>
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<td>----------</td>
</tr>
<tr>
<td>Which of the following is a cause of heart attack?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decreased blood flow to the heart</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chest pain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decreased blood flow to the brain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Over-doing a work-out</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 13</th>
<th>Multiple Choice</th>
<th>1 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>A stroke is</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reduced blood flow to the heart</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The result of a headache</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reduced blood flow to the brain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The result of a seizure</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 14</th>
<th>Multiple Choice</th>
<th>1 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>An atherosclerotic plaque is</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Build up of cholesterol within arteries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Build up of residue between teeth</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Build up of fungus underneath toe nails</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Build up of wax within the ear canal</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 15</th>
<th>Multiple Choice</th>
<th>1 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which of the following is TRUE about coronary bypass surgery?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prevents de-oxygenated blood from reaching the heart</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Restores blood flow to the brain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Restores blood flow to the heart</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prevents toxins from leaving the liver</td>
<td></td>
</tr>
</tbody>
</table>
**Question 16  Matching**

HDL and LDL are proteins produced by your body that transport cholesterol. Match each statement with the correct protein (HDL or LDL). Each protein will match more than once.

- This protein is UNHEALTHY when found in HIGH amounts in the blood stream.
  - A. HDL
  - B. LDL
- This protein is UNHEALTHY when found in LOW amounts in the blood stream.
- This protein delivers cholesterol to cells of the body.
- This protein returns cholesterol to the liver to be metabolized.

**Question 17  Multiple Choice**

In a healthy adult diet, how much fat should a person consume each day?

- No more than 5 grams
- No more than 25 grams
- No more than 45 grams
- No more than 65 grams

**Question 18  Multiple Choice**

A Quarter-Pounder with cheese from McDonalds contains how much of your daily allowance of fat?

- About 25% of your daily fat allowance
- About 50% of your daily fat allowance
- About 75% of your daily fat allowance
- About 100% of your daily fat allowance
<table>
<thead>
<tr>
<th>Question 1</th>
<th>Multiple Choice</th>
<th>1 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which of the following scenarios will result in weight gain?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Calorie expenditure &gt; calorie intake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Calorie expenditure = calorie intake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Calorie expenditure &lt; calorie intake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ All of the above</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 2</th>
<th>Multiple Choice</th>
<th>1 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which statement best describes what a calorie is?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ A calorie is a measure of weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ A calorie is a measure of energy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ A calorie measure how much nutrients are in food</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ A calorie is a measure of temperature</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 3</th>
<th>Multiple Choice</th>
<th>1 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which statement is true of anaerobic respiration?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Anaerobic respiration is the preferred method of generating ATP when oxygen is available.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Anaerobic respiration generates more ATP than aerobic respiration.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Anaerobic respiration produces less lactic acid than aerobic respiration.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Anaerobic respiration can occur without oxygen.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 4</th>
<th>Multiple Choice</th>
<th>1 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over a twenty four hour period, which activity burns the most calories?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Resting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Digesting food</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Exercising</td>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Thinking</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Question 5  Multiple Choice  1 points
Which organ is responsible for storing the majority of excess carbohydrate?

- Heart
- Liver
- Fat cells
- Arteries

Question 6  Matching  6 points
The statements on the left correspond with EITHER Aerobic respiration (choice A) or Anaerobic respiration (choice B). For each statement select the matching answer form of respiration.

- Produces lactic acid  □
- Requires oxygen  □
- Is used when sprinting  □
- Is used when holding your breath under water  □
- Is used when walking to class  □
- Generates more ATP  □

A. Aerobic respiration
B. Anaerobic respiration

Question 7  Multiple Choice  1 points
Which of the following does NOT occur as a result of aerobic exercise?

- HDL increases
- LDL decreases
- Insulin sensitivity increases
- Resting metabolic rate decreases

Question 8  Multiple Choice  1 points
Regular aerobic exercise reduces the risk of which of the following diseases?

- Diabetes
- Peripheral vascular disease
- Stroke
- Heart disease
- All of the above
Lab 4: Infectious Disease (Pre/Post Test)

Question 1  Multiple Choice  1 points
Which of the following statements is true?

[e] The presence of bacteria on the skin is normal
[e] The presence of bacteria on the skin is a sign of poor hygiene
[e] The presence of bacteria on the skin is a sign of skin infection
[e] The presence of bacteria on the skin occurs only in people with HIV

Question 2  Multiple Choice  1 points
Which of the following statements is NOT true about people who receive the flu vaccine?

[e] A certain percentage will get the flu from the vaccine.
[e] A certain percentage will get the flu because of a flu strain not covered by the vaccine.
[e] A certain percentage will get the flu because they were exposed to the virus before the vaccine could take effect.
[e] A certain percentage will get the flu because the vaccine failed to provide immunity.

Question 3  Multiple Choice  1 points
Which statement best explains why humans are not immune to the common cold?

[e] Overuse of antibiotics has resulted in stronger cold viruses.
[e] The cold virus has evolved so that it can escape our immune system.
[e] There are several viruses that cause the common cold and we are not immune to all of them.
[e] There are several bacteria that cause the common cold and we are not immune to all of them.

Question 4  Matching  6 points
Match each virus on the left with the method by which it is transmitted. The answer choices on the right can be used more than once.

- Flu virus
- Corona virus
- Rhino virus
- Hepatitis A
- Hepatitis B
- HIV

A. Airborne
B. Feco-oral
C. Sexually transmitted
**Question 5  Matching**  
7 points

The column on the left lists important components of the immune system. Match each component with its function on the right.

<table>
<thead>
<tr>
<th>Component</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antibody</td>
<td>A. Recognizes and destroys body cells infected with virus</td>
</tr>
<tr>
<td>B Cell</td>
<td>B. Filters old blood cells out of the bloodstream, as well as viruses and bacteria.</td>
</tr>
<tr>
<td>T cell</td>
<td>C. Produce antibodies</td>
</tr>
<tr>
<td>Spleen</td>
<td>D. Recognizes and attaches to foreign material</td>
</tr>
<tr>
<td>Bone marrow</td>
<td>E. Small pea sized structure found throughout the body and is a storage area for B and T cells</td>
</tr>
<tr>
<td>Macrophage</td>
<td>F. Cell that engulfs and destroys foreign material</td>
</tr>
<tr>
<td>Lymph node</td>
<td>G. Produces new red and white blood cells</td>
</tr>
</tbody>
</table>

**Question 6  Multiple Choice**  
1 points

Why do physicians treat a streptococcal throat infection with antibiotics?

- Treatment shortens the duration of illness
- Treatment prevents worsening of the infection
- Treatment prevents heart complications
- All of the above

**Question 7  Multiple Choice**  
1 points

Which of the following is the cause of drug resistant bacteria?

- Improper use of antibiotics.
- Travel to foreign countries without the appropriate vaccinations.
- The discovery of mad cow disease.
- The spread of bird flu from China.

**Question 8  Multiple Choice**  
1 points

The most effective way to prevent the spread of viruses and bacteria is

- Hand washing.
- Avoiding sick people.
- Wearing rubber gloves when cleaning.
- All of the above.
### Question 9  Multiple Choice  
Birth control pills are effective at

- Preventing the transmission of syphilis.
- Preventing the transmission of gonorrhea.
- Preventing the transmission of Chlamydia.
- Preventing pregnancy.
- All of the above.

### Question 10  Multiple Choice
Gonorrhea can be transmitted by

- Unprotected oral sex.
- Unprotected vaginal sex.
- Unprotected anal sex.
- All of the above.

### Question 11  Multiple Choice
Herpes is a sexually transmitted disease caused by

- A virus and CAN be cured with medication.
- A virus and CANNOT be cured with medication.
- A bacteria and CAN be cured with medication.
- A bacteria and CANNOT be cured with medication.

### Question 12  Multiple Choice
A cold caused by a virus

- Will get better faster if antibiotics are used.
- Will get better slower if antibiotics are used.
- Should not be treated with antibiotics because they have no effect on viruses.
- Should be treated with antibiotics only if the patient is very young or very old.
**Question 13**  Multiple Choice  1 points
Which of the following is NOT true about antibiotic resistant bacteria

- [ ] They are new species of bacteria that are being discovered for the first time.
- [x] They are common bacteria that have become immune to antibiotics.
- [ ] They are capable of causing death.
- [ ] They are commonly found in hospitals.

**Question 14**  Ordering  4 points
From the list below, which person is most likely to "catch a cold"? Organize the list starting with the person most likely to get a cold and ending with the person least likely to get a cold.

- Healthy breast fed infant
- Healthy senior citizen
- Healthy formula fed infant
- Healthy middle aged adult
Lab 5: Diagnostic Procedures (Pre/Post Test)

Question 1  Multiple Choice  1 points
A coronary angiogram is used to

☐ Open a blocked coronary artery
☐ Determine whether a coronary artery is blocked with plaque
☐ Bypass a blocked coronary artery
☐ All of the above

Question 2  Multiple Choice  1 points
Mammograms should be performed on women

☐ Regularly once a woman reaches puberty
☐ Regularly once a woman reaches the age of 40
☐ Regularly once a woman reaches menopause
☐ Only when the doctor or patient notices a lump in the breast

Question 3  Matching  6 points
Different diagnostic imaging tools use different types of energy to generate an image of what is inside your body.

Match the imaging tool on the left with the type of energy that is used to generate the image. The answers on the right may be used once, more than once, or not at all.

- Chest X-ray  A. Gamma ray
- Fetal Ultrasound  B. X ray
- MRI  C. Sonic energy
- Angiogram  D. Magnetic field
- CAT scan
- Echocardiogram

Question 4  Multiple Choice  1 points
The appropriate test to determine whether a heart valve is leaking is

☐ An x-ray
☐ A CAT scan
☐ A MRI
☐ An echocardiogram
☐ An EKG
Question 5  Multiple Choice  1 points
A stress test measures

☐ How well the heart responds to exercise
☐ How well the heart responds to job related stress
☐ How well the heart responds to the stress of an unhealthy lifestyle
☐ How well the heart responds to emotional stress
☐ All of the above

Question 6  Matching  4 points

This is a plane film (an X-ray) of the chest. Match the structure and the letter

- liver  A. A
- lung  B. B
- heart  C. C
- air in the stomach  D. D
Question 7  Multiple Choice  1 points
This image is a

- MRI
- CAT scan
- angiogram
- ultrasound
Question 8  Matching  2 points

Match

- MRI image
- CAT Scan image
Question 9  Multiple Choice  1 points
Identify the method that produced this image.

- CAT scan
- MRI
- CAT scan
- ultrasound

Question 10  Multiple Choice  1 points
STD testing should be offered annually to which group of people?

- All individuals after puberty
- All sexually active adolescents
- Only people sexually active with multiple partners
- Only men who have sex with men
Appendix D

*Student Activity Sheets*
Lab 1: Surface Anatomy and the Physical Exam

Introduction:

In this lab, you will study the surface of the body. During the lab, you will learn:
- Where important organs such as the heart, lungs and liver are located
- Where on the body these organs are closest to the surface
- How doctors choose where to listen, press and tap on the body to get information about organs inside the body

To help prepare you for the lab, there are some new vocabulary words that you should learn. After you have studied the vocabulary, complete the anatomy exercises on the next two pages. They will help you remember the function of important organs in your body as well as where they are located.

Vocabulary:

*Percuss*: to examine a body part by tapping on it.
This word is related to the word “percussion” as in a percussion instrument. To help you remember the definition of this word, remember that you play percussion instruments (like a drum) by tapping on them.

*Palpate*: to examine a body part using one’s hands and pressing.

*Auscultate*: to examine a body part by listening with a stethoscope

*Wheeze*: a high pitched lung sound often heard when auscultating the lungs of a patient with asthma

*Murmur*: an “extra” heart sound that can be normal, or can be a sign of a heart abnormality

*Physical exam*: the use of percussion, palpation and auscultation to gather information about the body. Doctors perform physical exams to gather information whenever they listen, tap or press on the body.
Each arrow points to an organ inside the body. Use the hints and your own knowledge to identify each organ.

The thorax (chest) is separated from the abdomen by the diaphragm. The diaphragm is a muscle underneath the lungs. You use this muscle to inflate your lungs when you breathe in.

Which organ from the exercise above is in the abdomen? (Hint: it is the organ below the diaphragm)

______________________________
Each arrow points to an organ within the abdomen. Use the hints and your own knowledge to identify each organ.

List three ways that a doctor can examine an organ:

_____________
_____________
_____________
Lab 2: Cardiovascular disease and the Cardiovascular Exam

Introduction:
In this lab, you will study the cardiovascular system. During the lab, you will learn:
- What structures compose the cardiovascular system
- What diseases affect the cardiovascular system
- The behaviors that increase the risk of cardiovascular disease
- How you can change your behavior to reduce the risk of cardiovascular disease in the future

To help prepare you for the lab, there are three exercises for you:
- Study the vocabulary below.
- On the next page you will find a diet diary, for the next five days starting tomorrow morning, record what you eat and drink (follow the instructions on the next page to see how). By the end of the exercise, you will have a good idea whether your diet is heart-healthy or not.
- Complete the coloring exercises found in this packet.

Vocabulary:

Cholesterol: a naturally occurring substance that is both produced by the body and found in our diet. Cholesterol is the building block of several hormones including testosterone and estrogen. We should limit our daily cholesterol intake to 300 mg/day. (One fried egg contains about 210 mg of cholesterol)

HDL: (High-density lipoprotein) is a protein produced by the body that scavenges for cholesterol and returns it to the liver for metabolism. High levels of HDL in the bloodstream are healthy.

LDL: (Low-density lipoprotein) is a protein produced by the body that delivers cholesterol from our diet to the cells of the body. The amount of LDL in our blood is a reflection of how much fat we consume. The lower the level, the healthier you are.

Atherosclerosis: the process by which arteries become narrowed by lipid and cholesterol containing plaque

Plaque: When referring to the cardiovascular system, plaque is a deposit of lipid and cholesterol within the wall of an artery. As plaques enlarge, they narrow the blood vessel and reduce the amount of blood that can flow through.

Hypertension: High blood pressure

Coronary bypass: surgery using a patient’s vein to bypass a coronary artery that is blocked with plaque

Balloon angioplasty: a minimally invasive surgery that opens a coronary artery that has been narrowed with plaque. The surgeon threads a deflated balloon through an artery in the groin up into the narrowed coronary artery. When in position, the balloon is inflated widening the artery and allowing blood to pass through the plaque.
Diet Diary

Many people who eat an unhealthy diet think they are eating a healthy diet. The best way to determine whether your eating habits are healthy, is to keep track of what you eat and record how much fat you eat each day. Your task is to determine if you are really eating a healthy diet—regardless of what you think.

For the next five days starting tomorrow morning, record everything you eat and drink on the charts provided in this packet. You will have to read the “Nutrition Facts” label on the food items that you consume. To properly fill out the chart you will need to know the following things about the things you eat and drink:

Columns 1 through 5
1. The Serving Size (found on “Nutrition Facts” label)
2. How many servings did you have? Be honest.
3. Calories per serving (found on “Nutrition Facts” label)
4. Calories from fat (found on “Nutrition Facts” label)
5. Grams of fat per serving (found on “Nutrition Facts” label)

These five pieces of information should be recorded in columns 1 through 5.

Column 6: Calories eaten
In this column, you will record how many calories are in the item you have eaten. You calculate this by multiplying the number of servings you had to the number of calories in each serving:

Column 6 = Column 2 x Column 3

Column 7: Fat Calories Eaten
In this column, you will record how many calories in the item you ate came from fat. You calculate this by multiplying the number of servings you had to the number of fat calories in each serving:

Column 7 = Column 2 x Column 4

Column 8: Grams of fat eaten
In this column, you will record how many grams of fat you ate. You calculate this by multiplying the number of servings you had to the grams of fat that were in each serving:

Column 8 = Column 2 x Column 5

Total
At the end of each day calculate:
1. Total calories consumed (sum of all numbers in Column 6)
2. Total calories from fat (sum of all numbers in Column 7)
3. Total grams of fat consumed (sum of all numbers in Column 8)

How are you doing each day? You should be consuming less than 65 grams of fat each day. Less than thirty percent of you total calories should be coming from fat. You can find out
how to calculate the percentage by using the formula found on the Summary Chart (last page).

Summary Chart
At the end of the five days, use the Summary Chart to determine how healthy your diet has been. Follow the instructions to fill out the chart.

You should carry the food diary with you so that you can fill it out as you eat. It will be nearly impossible to get the information you need if you try to fill out the table later because you won’t have the “Nutrition Facts” in front of you. If you are eating things that don’t have a “Nutrition Facts” label with them (like a burger from McDonald’s), then use the “Nutrition Facts” found on the next page to estimate how much fat you consumed.

You may be wondering: how many servings are there in a hamburger? By using the hand guide on the next page you can estimate how many servings are in the burger you’re eating. For example:

From the beef “Nutrition Facts” found on the next page, the serving size is 3 ounces (quarter pound). From the hand guide, 3 ounces is about the amount of meat that fits in the palm of your hand. So if you have one burger that fits in the palm of your hand, you’ve eaten one serving of beef. If you have a double cheeseburger, then that’s two palms full of beef. In this case you’ve had two servings.

You can use the hand guide for other difficult to measure food items.

At the end of each day, add up the numbers
An active adult should consume about 2,000 calories a day. No more than thirty percent of those calories should come from fat. The remainder should come from carbohydrates.

<table>
<thead>
<tr>
<th>Calories from fat</th>
<th>600  (30%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories from carbs</td>
<td>1400  (70%)</td>
</tr>
</tbody>
</table>

Total calories consumed 2000

One gram of fat contains nine calories. Therefore, a person should consume no more than 65 grams of fat each day (600 calories / 9 calories per gram = 66.6 grams of fat)

One gram of carbohydrate contains 3.75 calories. Thus, a person should consume around 375 grams of carbohydrates (1400 calories / 3.75 calories per gram = 373.3 grams of carb)
Estimating Portion Size when Eating Out or at Home

- FINGER Length
- Diameter of 1 fruit serving (tennis ball)
- FIST Volume
- One cup
- 2 Servings of cooked vegetables, pasta
- THUMB-TIP
- 1 tsp, 5 mL
- THUMB volume
- 2 tbsp, 30 mL
- 1 fl oz
- 1 serving of peanut butter
- 1 oz, 28 g
- 0.5 serving of cheese
- PALM of hand
- 100 g (3 oz) meat, fish, poultry, 1 to 2 servings
- Covered with nuts, snack chips, 1 portion

Nutrition Facts for Common Foods at Home

**Beef**

<table>
<thead>
<tr>
<th>Nutrition Facts</th>
<th>Serving Size 3 oz (85g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount Per Serving</td>
<td>Calories 195</td>
</tr>
<tr>
<td>Calories 195</td>
<td>Calories from Fat 102</td>
</tr>
<tr>
<td>Total Fat 7.5g</td>
<td>Total Fat 7.5g</td>
</tr>
<tr>
<td>Saturated Fat 3.9g</td>
<td>Saturated Fat 3.9g</td>
</tr>
<tr>
<td>Polyunsaturated Fat 2.0g</td>
<td>Polyunsaturated Fat 2.0g</td>
</tr>
<tr>
<td>Monounsaturated Fat 1.6g</td>
<td>Monounsaturated Fat 1.6g</td>
</tr>
<tr>
<td>Cholesterol 29mg</td>
<td>Cholesterol 29mg</td>
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<tr>
<td>Sodium 660mg</td>
<td>Sodium 660mg</td>
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<tr>
<td>Total Carbohydrate 3g</td>
<td>Total Carbohydrate 3g</td>
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<td>Dietary Fiber 0g</td>
<td>Dietary Fiber 0g</td>
</tr>
<tr>
<td>Sugars 0g</td>
<td>Sugars 0g</td>
</tr>
<tr>
<td>Protein 23g</td>
<td>Protein 23g</td>
</tr>
<tr>
<td>Vitamin A 0%</td>
<td>Vitamin A 0%</td>
</tr>
<tr>
<td>Vitamin C 0%</td>
<td>Vitamin C 0%</td>
</tr>
<tr>
<td>Calcium 2%</td>
<td>Calcium 2%</td>
</tr>
<tr>
<td>Iron 4%</td>
<td>Iron 4%</td>
</tr>
</tbody>
</table>

**Roasted Chicken**

<table>
<thead>
<tr>
<th>Nutrition Facts</th>
<th>Serving Size 1 unit (yield from 1 breaded-to-look chicken 32g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount Per Serving</td>
<td>Calories 95</td>
</tr>
<tr>
<td>Calories 95</td>
<td>Calories from Fat 6g</td>
</tr>
<tr>
<td>Total Fat 6.7g</td>
<td>Total Fat 6.7g</td>
</tr>
<tr>
<td>Saturated Fat 1.9g</td>
<td>Saturated Fat 1.9g</td>
</tr>
<tr>
<td>Polyunsaturated Fat 1.7g</td>
<td>Polyunsaturated Fat 1.7g</td>
</tr>
<tr>
<td>Monounsaturated Fat 2.9g</td>
<td>Monounsaturated Fat 2.9g</td>
</tr>
<tr>
<td>Cholesterol 28mg</td>
<td>Cholesterol 28mg</td>
</tr>
<tr>
<td>Sodium 27mg</td>
<td>Sodium 27mg</td>
</tr>
<tr>
<td>Total Carbohydrate 6g</td>
<td>Total Carbohydrate 6g</td>
</tr>
<tr>
<td>Dietary Fiber 0g</td>
<td>Dietary Fiber 0g</td>
</tr>
<tr>
<td>Sugars 0g</td>
<td>Sugars 0g</td>
</tr>
<tr>
<td>Protein 5.8g</td>
<td>Protein 5.8g</td>
</tr>
<tr>
<td>Vitamin A 2%</td>
<td>Vitamin A 2%</td>
</tr>
<tr>
<td>Vitamin C 0%</td>
<td>Vitamin C 0%</td>
</tr>
<tr>
<td>Calcium 1%</td>
<td>Calcium 1%</td>
</tr>
<tr>
<td>Iron 3%</td>
<td>Iron 3%</td>
</tr>
</tbody>
</table>

**Pan-fried Pork chop**

<table>
<thead>
<tr>
<th>Nutrition Facts</th>
<th>Serving Size 1 chop, excluding bone (yield from 1 raw chop, with bone; weighing 151 g (5.3 oz))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount Per Serving</td>
<td>Calories 284</td>
</tr>
<tr>
<td>Calories 284</td>
<td>Calories from Fat 34%</td>
</tr>
<tr>
<td>Total Fat 35g</td>
<td>Total Fat 35g</td>
</tr>
<tr>
<td>Saturated Fat 20g</td>
<td>Saturated Fat 20g</td>
</tr>
<tr>
<td>Polyunsaturated Fat 5g</td>
<td>Polyunsaturated Fat 5g</td>
</tr>
<tr>
<td>Monounsaturated Fat 5g</td>
<td>Monounsaturated Fat 5g</td>
</tr>
<tr>
<td>Cholesterol 70mg</td>
<td>Cholesterol 70mg</td>
</tr>
<tr>
<td>Sodium 550mg</td>
<td>Sodium 550mg</td>
</tr>
<tr>
<td>Total Carbohydrate 3g</td>
<td>Total Carbohydrate 3g</td>
</tr>
<tr>
<td>Dietary Fiber 0g</td>
<td>Dietary Fiber 0g</td>
</tr>
<tr>
<td>Sugars 0g</td>
<td>Sugars 0g</td>
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<tr>
<td>Protein 17g</td>
<td>Protein 17g</td>
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<tr>
<td>Vitamin A 0%</td>
<td>Vitamin A 0%</td>
</tr>
<tr>
<td>Vitamin C 0%</td>
<td>Vitamin C 0%</td>
</tr>
<tr>
<td>Calcium 2%</td>
<td>Calcium 2%</td>
</tr>
<tr>
<td>Iron 4%</td>
<td>Iron 4%</td>
</tr>
</tbody>
</table>

**Catfish, Breaded Pan-fried**

<table>
<thead>
<tr>
<th>Nutrition Facts</th>
<th>Serving Size 3 oz (85g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount Per Serving</td>
<td>Calories 195</td>
</tr>
<tr>
<td>Calories 195</td>
<td>Calories from Fat 102</td>
</tr>
<tr>
<td>Total Fat 7.3g</td>
<td>Total Fat 7.3g</td>
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<td>Saturated Fat 3.5g</td>
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<td>Polyunsaturated Fat 2.0g</td>
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<td>Monounsaturated Fat 1.8g</td>
<td>Monounsaturated Fat 1.8g</td>
</tr>
<tr>
<td>Cholesterol 29mg</td>
<td>Cholesterol 29mg</td>
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<tr>
<td>Sodium 110mg</td>
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<td>Dietary Fiber 0g</td>
<td>Dietary Fiber 0g</td>
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<td>Vitamin C 0%</td>
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<td>Calcium 4%</td>
<td>Calcium 4%</td>
</tr>
<tr>
<td>Iron 7%</td>
<td>Iron 7%</td>
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</tbody>
</table>
# Day 1 Food Item

<table>
<thead>
<tr>
<th></th>
<th>Serving Size</th>
<th># of serv eaten</th>
<th>Cal/serving (from label)</th>
<th>Fat cal/serv. (from label)</th>
<th>Grams fat (from label)</th>
<th>Cal eaten (2 x 3)</th>
<th>Fat Cal eat (2 x 4)</th>
<th>Fat eaten (g) (2 x 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakfast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lunch</td>
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<td></td>
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<tr>
<td>Dinner</td>
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</tr>
<tr>
<td>Snacks/Other</td>
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</tr>
<tr>
<td>Total (6,7 &amp; 8)</td>
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<td></td>
</tr>
<tr>
<td>Food Item</td>
<td>1 Serving Size</td>
<td>2 # of serv eaten</td>
<td>3 Cal/serving (from label)</td>
<td>4 Fat cal/serv. (from label)</td>
<td>5 Grams fat (from label)</td>
<td>6 Cal eaten (2 x 3)</td>
<td>7 Fat Cal eat (2 x 4)</td>
<td>8 fat eaten (g) (2 x 5)</td>
</tr>
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<td>Breakfast</td>
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<td>Snacks/Other</td>
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</tr>
<tr>
<td>Food Item</td>
<td>1 Serving Size</td>
<td>2 # of serv eaten</td>
<td>3 Cal/serving (from label)</td>
<td>4 Fat cal/serv. (from label)</td>
<td>5 Grams fat (from label)</td>
<td>6 Cal eaten (2 x 3)</td>
<td>7 Fat Cal eat (2 x 4)</td>
<td>8 fat eaten (g) (2 x 5)</td>
</tr>
<tr>
<td>-----------</td>
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<td>------------------------------</td>
<td>------------------------</td>
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<tr>
<td>Breakfast</td>
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<td></td>
</tr>
<tr>
<td>Lunch</td>
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<td>Food Item</td>
<td>1 Serving Size</td>
<td>2 # of serv eaten</td>
<td>3 Cal/serving (from label)</td>
<td>4 Fat cal/serv. (from label)</td>
<td>5 Grams fat (from label)</td>
<td>6 Cal eaten (2 x 3)</td>
<td>7 Fat Cal eat (2 x 4)</td>
<td>8 fat eaten (g) (2 x 5)</td>
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### Day 5

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<th>2 # of serv eaten</th>
<th>3 Cal/serving (from label)</th>
<th>4 Fat cal/serv. (from label)</th>
<th>5 Grams fat (from label)</th>
<th>6 Cal eaten (2 x 3)</th>
<th>7 Fat Cal eat (2 x 4)</th>
<th>8 fat eaten (g) (2 x 5)</th>
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</table>
Summary Chart

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<thead>
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<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
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<tbody>
<tr>
<td></td>
<td>Tot Cal</td>
<td>Tot Fat Cal</td>
<td>Tot Fat (g)</td>
<td>% Cal from Fat</td>
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<tr>
<td>Day 1</td>
<td></td>
<td></td>
<td>Goal &lt; 65g/day</td>
<td>Goal &lt; 30%</td>
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<tr>
<td>Day 2</td>
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<td>Day 3</td>
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<td>Day 5</td>
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</tbody>
</table>

Instructions:

Column A: For each day, write the total from the bottom of column 6 in column A.

Column B: For each day, write the total from the bottom of column 7 in column B.

Column C: For each day, write the total from the bottom of column 8 in column C.

Column D: Use the formula below to calculate the value for Column D

\[
\% \text{ Calories from Fat} = \frac{\text{B}}{\text{A}} \times 100
\]

Do you have a healthy diet?

Healthy diet = Column C < 65 grams for each day AND Column D < 30% for each day
Lab 3: Energy Management in the Human Body

Introduction:

The goal of this lab is to help you understand how and why we gain or lose weight. With this knowledge I hope you will be able to make informed decisions about your health. It is important to stress that while behavior, in terms of what we eat and how much we exercise, is an important factor in body weight; genetics is now seen as an important determinant of each person’s weight set point.

To help prepare you for the lab, there are three exercises for you:

1. Study the vocabulary below
2. Read the material in this handout about Energy Management. The reading is designed to answer questions that you might have asked yourself, but never found the answer. Questions such as:
   - What happens to the fats and carbohydrates in our diet once we’ve eaten them?
   - Why is it more difficult for some people to maintain a healthy body weight?
   - What is aerobic exercise and why is it important?
3. Complete the questions at the end of the reading.

Vocabulary:

Food calorie: unit of energy equivalent to 1 kilocalorie. A kilocalorie is defined as the amount of energy required to raise the temperature of 1 liter of water by one degree Celsius.

Resting Metabolic Rate: the number of calories the body uses passively; for example, calories used to maintain body temp, conduct ventilation, pump blood etc.

Thermic Effect of Feeding: the calories spent to digest food.

Thermic Effect of Activity: calories spent doing voluntary activities; for example, walking, running, fidgeting.

Total Energy Expenditure: the total number of calories spent each day; that is, the sum of Resting Metabolic Rate, Thermic Effect of Feeding, and Thermic Effect of Activity.

Aerobic respiration: the body’s preferred method of generating energy. Aerobic respiration uses oxygen to release energy from food. The use of oxygen in the energy release process allows more ATP to be generated per gram of substrate. Furthermore, aerobic respiration does not result in fatigue, because no lactic acid is produced.

Anaerobic respiration: less efficient method of energy generation when oxygen supplies are limited. Anaerobic respiration does not use oxygen, and therefore does not generate as much ATP as aerobic respiration. Anaerobic respiration produces lactic acid as a waste product which causes muscle fatigue.
**What is metabolism?**
Metabolism is a word we use to describe the chemical reactions that occur in our bodies. In general, there are two major types of reactions that take place in our cells: anabolic reactions and catabolic reactions. Anabolic reactions are those that create larger molecules from smaller ones. These reactions usually require energy to make them happen. For example, building large complex proteins from small simple amino acids is an anabolic reaction that requires energy. Catabolic reactions are reactions that create smaller molecules from larger molecules. Usually, these reactions do not require large amounts of energy—quite often these reactions release energy. When ATP, the molecule that our bodies use for energy, is catabolized to ADP (a smaller molecule) energy is released.

Our bodies perform metabolism to achieve several goals. Anabolism allows us to grow and repair our bodies by creating complex molecules like myosin for our muscles and collagen for our skin. Both myosin and collagen are complex proteins that are made from smaller amino acids. Catabolism allows us to access stored fats and carbohydrates from large storage molecules when we need energy. Anabolism allows us to build those storage molecules from the fats and the carbs that we eat.

**What happens to the fats and carbohydrates in our diet once we’ve eaten them?**
The carbs and fats we consume have one of two fates: they can be utilized immediately after being absorbed to form ATP, the substance that drives almost every energy requiring activity (such as muscle contractions and anabolic reactions); or they can be stored for later use if energy is already abundant. Fats, once digested, are easily stored in adipose tissue for later use. If energy is scarce, the liver will metabolize lipid to fatty acids and glycerol which can be absorbed by tissue and used for energy. Carbs, which are digested to monosacharides before being absorbed, can be metabolized to create ATP, or they can be stored as glycogen within the liver and skeletal muscle. While excess carbs can be stored as fat, this is not the primary storage form for carbs, because of the energy investment required to convert carbs to fat is quite high. 23% of the energy found in carbs is lost when the body must convert it to fat. Storing ingested fats is much less expensive, only about 3% of the energy found in fats is lost in storage.

**What is ATP?**
ATP stands for adenosine triphosphate. The prefix tri means three and reminds us that ATP has three phosphate groups (see the diagram below). ATP is the fuel that cells use to perform work. The energy in ATP is stored in three phosphate bonds that connect the phosphate groups to each other and the anchoring ribose molecule. This energy can be quickly released by breaking these bonds one at a time. When a phosphate bond in ATP is broken, energy is released along with one phosphate group. The remaining molecule now has two phosphate groups and is called ADP, or adenosine diphosphate (meaning two phosphate groups). ADP can be recharged, back to ATP by accepting energy from fats or carbs through respiration. In order for the food we eat to be used for energy, it must be stored within the phosphate bonds of ATP. By using a process called respiration, our bodies can take the energy found in carbs and use it to create the high energy phosphate bonds in ATP. Both fats and carbs can regenerate ATP from ADP. In general, fats generate more ATP per gram than carbs. This is why fats are calorie rich compared to carbs. Remember that a gram of carb contains 3.75 calories while a gram of fat contains 9 calories. In molecular terms, 1 mole of glucose yields 36 moles of ATP while one mole of an 18 carbon fat yields 147 moles of ATP.

\[
\begin{align*}
1 \text{ gram of carbohydrate} & = 3.75 \text{ calories} \\
1 \text{ gram of fat} & = 9 \text{ calories} \\
\text{OR} & \\
1 \text{ mole of glucose} & = 36 \text{ moles of ATP}
\end{align*}
\]
1 mole of fat = 147 moles of ATP

Chemical Properties of ATP (Adenosine Triphosphate)

[Diagram of ATP structure]

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**How do our bodies convert fats and carbs into ATP?**

Evolution has provided two mechanisms of converting energy in fats and carbs to energy in ATP: namely aerobic and anaerobic respiration. Anaerobic respiration is likely to have evolved first. This mechanism of transferring energy from glucose to ATP is much simpler than aerobic respiration—it requires fewer enzymes, does not require oxygen and does not require mitochondria (a collaboration that happened well after cellular life began). Understandably, this simpler method of producing ATP yields smaller amounts of ATP than aerobic respiration. For every mole of glucose respired anaerobically, two moles of ATP are generated.

The advent of aerobic respiration incorporates several new enzymes to the process and requires the presence of oxygen to regenerate electron carriers that are reduced as glucose is metabolized. Aerobic respiration is a more profitable way of generating ATP, because more bonds within the glucose (or fat) molecule are broken, thereby releasing more energy. Whereas anaerobic respiration generates 2 moles of ATP per mole of glucose, aerobic respiration generates 36 moles of ATP per mole of glucose.

**Aerobic Respiration:** Generates 36 moles of ATP per mole of glucose

**Anaerobic Respiration:** Generates 2 moles of ATP per mole of glucose

Both aerobic and anaerobic respiration have advantages and disadvantages. It is the balance between benefit and cost that determines the ratio of aerobic to anaerobic respiration that occurs in the body. The ratio is constantly changing depending on the body’s energy needs and the availability of oxygen. Clearly, the advantage to aerobic respiration is that it produces more ATP than anaerobic respiration. The drawback is that aerobic respiration is dependant upon a steady supply of oxygen. The maximum amount of oxygen our blood can extract from the air we breathe defines our maximum aerobic energy output. Thus when we exercise, we reach a point where our muscle’s demand more oxygen than our lungs can supply.
If it is imperative that we continue to work despite oxygen demands that exceed our bodies’ ability to deliver oxygen to cells, then anaerobic respiration begins to supplement our energy requirements. Anaerobic respiration produces ATP without increasing our oxygen requirement. Thus the advantage of anaerobic respiration is its ability to provide ATP without increasing oxygen demands. The disadvantage of anaerobic respiration is its waste product: lactic acid. Without oxygen, lactic acid cannot be broken down. Lactic acid is what causes our muscles to burn when we perform strenuous exercise. It is the buildup of lactic acid that gives us the sensation of fatigue, which ultimately causes us to stop doing what we’re doing. We have all noticed that the burning sensation gradually goes away once we stop exercising. Once we stop exercising, our energy requirement decreases and oxygen that had previously been used to conduct aerobic respiration can now be used to remove lactic acid—this is one of the reasons why we continue to pant just after stopping exercise.

**How do I know if I have a healthy body weight?**

Often times, what culture tells us is healthy is not the same as what a physician would think is healthy. Ideal body weight is a good example. Most often media portrays ideal body weight as unrealistically slim; take a look at almost any clothing model. Occasionally, ideal body weight is portrayed as unrealistically heavy—Biggy and Big Pun come to mind. In the end, what’s important, is not what media tells us is desirable, but what is in the best interest of our health. Therefore, it is important to have a conversation with your physician about what an appropriate body weight is. A healthy body weight depends on how tall we are. The chart below shows what the target weight should be based on that person’s height. Being significantly overweight or significantly underweight can cause health problems.

**Using the Height/Weight Chart**

Most people know their height in terms of feet and inches. For example, I am five feet eight inches tall. The height/weight chart below, requires you to know your height in centimeter. Once you know your height in centimeters, the chart will tell you your ideal weight in kilograms. In this section you will learn how to convert your height into centimeters. Once you’ve found your ideal weight in kilograms, you can use this section to convert that weight into pounds.

1. Convert your height into inches. For example I am 5 feet 8 inches tall.
   
   \[
   \text{5 feet x 12 inches per foot} = 60 \text{ inches} \\
   \text{60 inches + 8 inches} = 68 \text{ inches}
   \]
   Thus 5ft 8in = 68 inches

2. Convert inches to centimeters.
   
   \[
   \text{1 inch} = 2.54 \text{ cm}
   \]
   
   \[
   \text{68 inches x 2.54 cm per inch} = 172.7 \text{ cm}
   \]

3. Find 172.7cm on chart and read corresponding healthy weight range from x-axis
   
   Healthy weight range = ~ 55 – 73 kg

4. Convert kg to pounds
   
   \[
   \text{1 kg} = 2.2 \text{ pounds} \\
   \text{55kg} \times 2.2 \text{ pounds per kg} = 121.3 \text{ pounds}
   \]
   
   \[
   \text{73kg} \times 2.2 \text{ pounds per kg} = 160.9 \text{ pounds}
   \]
Thus, the healthy weight range for a person 5ft 8in tall (like myself) is between 120 and 160 pounds.

What determines whether I gain or lose weight?

Changes in body weight depend on the balance between calories consumed in food and calories “burned” by the body. We have already talked about calorie consumption. In the last lab session, we monitored our calorie intake. While the average adult should consumer around 2100 calories a day, consuming fewer than 2100 calories does not guarantee that a person will lose weight; and consuming more than 2100 calories doesn’t guarantee that a person will gain weight. In order to determine whether a person’s weight will increase, decrease or stay the same, we must compare their daily calorie consumption with their daily calorie expenditure (the number of calories they burn).
Most people think that the only way the body burns calories is by exercising. While exercise is an important part of burning calories, it is not the only way. In fact, most of the calories you burn during the day are burned when you are not exercising. There are three ways that your body burns calories:

1. While resting (resting metabolic rate): When we rest our bodies do not stop. Our heart is still beating, our brains require constant supplies of energy in the form of glucose to keep it working, our diaphragms must continuously work to allow us to breathe, we must maintain body temperature etc. All of these activities happen while we are at rest, and they all require energy. About 60% of our daily calorie expenditure is the result of activities our bodies perform while we are “at rest”.

2. While digesting (thermic effect of feeding): Digesting food is hard work! Why do you think people complain of “food-coma” or “the itis” after eating a large meal? It takes energy for our digestive system to process the food we eat. Luckily in the long run, the amount of energy that our bodies get out of the food we eat is greater than the amount of energy we must invest to digest it. About 10% of our daily calorie expenditure is the result of digestion.

3. While exercising (thermic effect of activity): In this case exercise means any voluntary action, such as scratching your head, walking to class, playing sports, talking to your classmate when you’re not supposed to etc. Depending on how active you are, 15-30% of your daily calorie expenditure is the result of exercise.

When added together, these three methods of burning calories equal your total energy expenditure. With this in mind, we can write the following equation:

\[
\text{Total energy expenditure} = \text{Resting metabolic rate} + \text{Thermic effect of feeding} + \text{Thermic effect of Activity}
\]

Now that we understand how our bodies use energy, we can predict when a person’s weight will increase, decrease or stay the same. If a person’s total energy expenditure equals their calorie intake, then their weight will stay the same. If a person’s total energy expenditure is less than their calorie intake, then their weight will increase. If a person’s total energy expenditure is greater than their calorie intake, then their weight will decrease:

\[
\text{Total energy expenditure} = \text{Caloric Intake} \quad \text{Weight Stable}
\]

\[
\text{Total energy expenditure} < \text{Caloric intake} \quad \text{Weight Gain}
\]

\[
\text{Total energy expenditure} > \text{Caloric intake} \quad \text{Weight Loss}
\]

**Why is it more difficult for some people to maintain a healthy body weight?**

We all know someone who is remarkably lean, yet she eats whatever she wants and never seems to exercise. What is it that makes life so simple for her? It turns out that the resting metabolic rate is not the same for everyone. In other words, some people burn more calories while resting and others burn less. So that girl who eats all she wants and never gains a pound most likely has a higher than average resting metabolic rate, which allows her to burn more calories each day.

**Can a person’s Resting Metabolic Rate be changed?**
So maybe, you’re one of those people who is not as lucky as the girl we were talking about above and you’re wondering if there is a healthy way to increase your resting metabolic rate. Luckily, there are several factors that can increase or decrease your resting metabolic rate, but it’s not all good news. Genetics and age seem to be major players in determining a person’s resting metabolic rate. Unfortunately, as we get older, our resting metabolic rate decreases. Or as people like to say “your metabolism starts to slow down”. Furthermore, some families tend to have lower resting metabolic rates than others.

The good news is: everyone has the ability to increase their resting metabolic rate, regardless of age. Thirty minutes of aerobic exercise a day combined with a modest diet low in fats, significantly increases your resting metabolic rate. So exercising regularly is like getting two good things for the price of one: you burn lots of calories while you exercise, and after a while, your body responds to the exercise by burning more calories while you rest.

Now here’s the news that many people don’t know: very low calorie diets causes the body’s resting metabolic rate to decrease. This is an adaptation that mammals developed many years ago when food was much more scarce than it is today. During periods of food shortage, animals who could burn fewer calories while resting were able to save energy for when they really needed it: to escape from a predator’s chase, or to hunt for food when it was discovered. We still carry this adaptation and it kicks in whenever we starve ourselves. So, dieters beware: a very low calorie diet may make weight loss even more difficult!

Obviously, a person can change the thermic effect of activity by increasing or decreasing the amount they exercise. But can a person change their resting metabolic rate? The answer is yes. Both exercise and diet affect your resting metabolic rate.

**What is aerobic exercise and why is it important?**

Many people think that aerobic exercise must involve a room full of people wearing spandex, stepping up and down off of plastic blocks, all in front of a great big mirror. While this is indeed aerobic exercise, almost any exercise activity is aerobic if performed in a certain way. Aerobic exercise is any activity that favors aerobic respiration while increasing your heart rate. Brisk walking, jogging, most sports, dancing etc can be considered aerobic exercise if performed long enough to elevate your heart rate.

Everyone should engage in aerobic exercise because there are many benefits. Most importantly, aerobic exercise improves your cardiovascular health. Your heart is a muscle and like other muscles in your body, it responds better to stress if it gets exercise. Daily aerobic exercise also increases HDL (“good cholesterol”) and decreases LDL (“bad cholesterol”). These benefits in cholesterol reduce your likelihood of developing heart disease in the future. Daily aerobic exercise also improves your body’s response to insulin. An improved insulin response reduces your risk of developing diabetes. Finally, for those who are looking to increase their calorie expenditure, aerobic exercise burns many more calories than anaerobic exercise.

**What is the difference between aerobic exercise and anaerobic exercise?**

The difference between the two is intensity. In aerobic exercise, the goal is NOT to exercise as hard as you can because your oxygen demands will quickly exceed your body’s ability to deliver oxygen to your muscles. When this happens anaerobic respiration kicks which produces lactic acid and your muscles become fatigued. Fatigue is not very helpful because it makes you stop exercising. So, aerobic exercise is moderate intensity exercise that favors aerobic respiration without pushing yourself to the point of fatigue. It burns more calories than anaerobic exercise and is more pleasant.
Anaerobic exercise is useful particularly with athletes who need to be able to perform in short quick bursts, such as sprinters. During a sprint, an athlete pushes him or herself to the max immediately. By pushing themselves to the max sprinters demand more power from their bodies than aerobic respiration can give. Anaerobic exercise gives them the ability to tolerate anaerobic respiration for longer periods of time giving them a competitive edge.

**Food is not the Enemy and Exercise is Your Friend**

Now that we have discussed the idea of balancing calorie intake with energy expenditure, we have to determine what the best way to achieve this balance is. Most diet programs require people to give up foods that we enjoy. Giving up foods we like sometimes makes it even more difficult not to eat them. For that reason, complete abstinence from our favorite foods is not the most successful way toward a healthier diet. Instead, we should be aware of what is in the foods that we eat as well as how active we are. Part of the reason why we completed diet diaries over the holiday break was to help us become more aware of what we are putting into our bodies. Hopefully, you have a better idea of what foods are high in calories and what foods are not. Knowing this, you can make healthier food choices: you can still enjoy the foods you like, but now you can be smart about how often you eat calorie rich foods.

Within the next few weeks, you will receive a pedometer. A pedometer is a pager sized device that you wear on your belt. It counts the number of steps you take and can help you determine how active you are and estimate how many calories you burn in a day. Knowing both your calorie intake and your calorie expenditure will help you make better food and exercise choices.

Exercise should always be an enjoyable experience and you should find activities that are reasonable for you. For some people, exercising is as simple as walking each day instead of taking the bus, or getting off a few stops early and walking the rest. Others like to play sports, take walks, jog outdoors or on a treadmill. The key is to not overwhelm yourself in the beginning. Start gradually and work yourself up to 30 minutes of exercise a day.

**Study Questions**

1. List three factors that effect resting metabolic rate:

   __________________________

   __________________________

   __________________________

2. What factors determine whether a person loses or gains weight?

   __________________________________________

   __________________________________________

   __________________________________________
3. Why can’t our bodies use anaerobic respiration all the time?

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

4. Which type of respiration allows you to hold your breath while under water?

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

5. Why can’t you hold your breath under water indefinitely?

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

6. Take a moment and think about three realistic ways you can increase daily aerobic exercise. What are they?

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

7. Using the height/weight chart on page five, find the healthy weight range that corresponds to your height.
   
   Height in inches ________  Height in cm ________

   Wt range in kg ________  Wt range in pounds ________
Lab 4: Infectious Disease

Introduction:

The goal of this lab is to understand how your body protects you against infection. You will learn about the different types of organisms that commonly cause infection and how they overcome our bodies’ natural self-defense system (the immune system). By the end of the lab, you should know what you can do to reduce the likelihood of getting an infection as well as what physicians can do to prevent infection or fight infections when they do occur.

To help prepare you for the lab, there are three exercises for you:

4. Study the vocabulary below
5. Read the material in this handout about Infectious Disease. The reading is designed to answer questions that you might have asked yourself, but never found the answer. Questions such as:
   - How come we get sick even though we have an immune system?
   - How do antibiotics work?
   - Why don’t humans become immune to the common cold?
6. Complete the questions at the end of the reading.

Vocabulary:

**Virus:** an intracellular parasite composed of a core containing either DNA or RNA covered by a protein coat. Viruses are not capable of reproducing on their own, instead they rely upon the cells they infect for reproduction

**Bacteria:** cellular organisms that, in almost all cases, are capable of extracellular reproduction

**Parasites:** this category includes protozoa (single celled parasites such as malaria) and multicellular helminthes (worms such as tape worm)

**Antibiotic medication:** a drug that has the ability to weaken or kill foreign cellular invaders

**Antiviral medication:** a drug that has either interrupts viral replication or magnifies the body’s response to viral invasion

**Vaccine:** a substance that causes the recipient to develop temporary or lifelong immunity to a specific infectious disease

**Immune system:** a complex system of cells and proteins that defends the body against infection

**Antibody:** a protein produced by B cells that attaches to foreign invaders and marks them for destruction by macrophages

**B cell:** Produce antibodies

**T cell:** these cells recognize foreign material, especially virus infected cells. T cells respond by destroying infected cells
What causes an infection?

An infection is caused by the presence of a foreign organism. The types of organisms that cause infection are bacteria, fungi, parasites and viruses. Not all foreign organism cause infection. In fact, bacteria are normally found in several parts of our bodies. Bacteria are normally found on our skin. Bacteria in our digestive tract aid digestion. The absence of normal bacteria can cause problems. Antibiotics kill both normal and harmful bacteria. Commonly, antibiotics kill normal bacteria in the digestive tract while doing their job. Some of the side-effects of antibiotics are due to the elimination of normal bacteria. You or someone you know may have experienced diarrhea after taking antibiotics for an infection. The diarrhea is caused by abnormal digestion in the absence of normal bacteria in the digestive tract.

Viruses

Viruses are microscopic particles, much smaller than a cell. The contents of a viral particle are quite limited due to its small size. A typical viral particle contains a core and an outer protein coat. The core contains either a strand of DNA or RNA which contains the instructions for making more virus. Without organelles, such as mitochondria, nuclei and ribosomes, there is not much that a virus can do on its own. This include reproduction. Viruses only become active when they are inside of cells. The DNA or RNA exits the core. The infected cell is tricked into believing that the viral RNA or DNA belongs to the cell. The cell follows the instructions found in the viral genetic material to manufacture hundreds of new viral particles. Once the cell is filled with virus the cell bursts, releasing virus to the cells around it.

<table>
<thead>
<tr>
<th>Virus</th>
<th>Disease</th>
<th>Mode of Transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influenza</td>
<td>Flu</td>
<td>Airborne: virus found in droplets expelled into the air when an infected person coughs</td>
</tr>
<tr>
<td>Coronavirus</td>
<td>Common Cold</td>
<td>Airborne</td>
</tr>
<tr>
<td>and Rhinovirus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hepatitis A</td>
<td>Hepatitis (Liver Disease)</td>
<td>Feco-oral: virus found in feces and transmitted by ingestion. For example an infected food handler fails to wash hands after using the restroom then touches food which a customer eats resulting in spread of virus.</td>
</tr>
<tr>
<td>Hepatitis B</td>
<td>Hepatitis</td>
<td>Blood borne: IV drug use, sexual contact, mother to fetus</td>
</tr>
<tr>
<td>HIV</td>
<td>AIDS</td>
<td>Blood borne: IV drug use, sexual contact, mother to fetus</td>
</tr>
</tbody>
</table>

Bacteria

Unlike viruses, bacteria are cellular organisms. Bacteria have nuclei, ribosomes, and some have mitochondria. Most bacteria are capable of living outside of human cells. They can use nutrients to generate energy that drives the process of reproduction.

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>Disease</th>
<th>Mode of Transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>E. coli</td>
<td>Gastroenteritis (diarrhea)</td>
<td>Food borne: undercooked beef and poultry products</td>
</tr>
<tr>
<td></td>
<td>Strep throat</td>
<td>Normal flora: streptococci are bacteria that are normally found in the mouth, throat and on the</td>
</tr>
</tbody>
</table>
Meningitis skin. Streptococci cause disease when they invade beyond the surface of the oral cavity or skin, or gain access to the blood.

| Mycobacterium tuberculosis | Tuberculosis | Airborne |

**Parasites**
Parasites are a category of infection that include protozoa (single celled organisms) and helminthes (worms, which are multicellular)

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Disease</th>
<th>Mode of Transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasmodium</td>
<td>Malaria</td>
<td>Mosquito borne</td>
</tr>
<tr>
<td>Taenia solium</td>
<td>Diarrhea, brain cysts</td>
<td>Eating Undercooked pork</td>
</tr>
<tr>
<td>Trichomonas</td>
<td>Vaginitis in women</td>
<td>Transmitted through sexual contact</td>
</tr>
<tr>
<td></td>
<td>Urethritis in men</td>
<td></td>
</tr>
</tbody>
</table>

**Fungi**
Fungi are composed of molds and yeast. They are virtually everywhere including the air. We are continuously being exposed to fungi, but unlike bread that has been sitting out for too long, our bodies are well equipped to prevent major fungal infections. In a healthy person, fungal infections, while often annoying, are rarely life threatening. In people who are immunocompromised, fungal infections can be deadly. Fungal infections are treated with specific antifungal medications that target the fungal cell membrane. Ringworm, athlete’s foot, nail bed discoloration, vaginal yeast infections and its male equivalent commonly referred to as “jock itch” are all caused by fungal infections.

**How do our bodies prevent infection?**
Think about what happens to a piece of meat that is left out of the refrigerator. After a day it begins to change color, it starts to smell and it is clear that it is beginning to rot. Bacteria begin to grow and if left out long enough, flies will lay eggs on it and larvae will begin to grow. What prevents this from happening to the meat when it was living? How come the same does not happen to the muscles and tissues of our living bodies?

Our bodies are constantly protecting us from infection. The best way to fight infection is to prevent them in the first place. Our bodies have become very good at preventing infection. The first adaptation that our bodies have to prevent infection is a barrier: our skin. Skin, under normal circumstance cannot be penetrated by the organisms that cause infection. While infectious organisms can land on our skin, as long as they do not penetrate our skin, we are protected from infection.

If it were possible for our skin to have no openings whatsoever, we may have been able to avoid most infections altogether. But, we need openings to eat with, to eliminate waste with, to see and hear with and so on. Despite having openings, our bodies have developed mucous membranes which provide a layer of protection on these openings that makes it more difficult for organisms to gain entry through our skin’s larger openings.

Mucous membranes are moist surfaces made of a specialized type of cell called squamous epithelium. Mucous membranes can be found in almost any opening of the body. Mucous membranes cover the inside of our mouths, the lining of the respiratory tract, the inner sides of our eyelids and the openings...
of our genetalia. The cells of squamous epithelium are layered tightly to make it difficult for infectious organisms to penetrate. The moist mucous found on the surface of mucous membranes provides an additional barrier and washes away organisms that land on the surface. In addition, mucous contains antibodies and immune cells that work to fight off organisms as they arrive.

**If our bodies fail to prevent infection, what do our bodies do to fight off infection?**

Unfortunately, our skin and mucous membranes are not 100% effective in preventing infectious organisms from entering our bodies.

There are several factors that can result in an organism penetrating our skin or mucous membranes. Here are a few:

- Damage to the surface such as cuts, scrapes and tattoos
- Skin penetration, for example new body piercings, intravenous drug use, puncture wounds, mosquito bites in the case of malaria
- Weakening of the squamous epithelium due to cigarette smoking, chewing tobacco and other tobacco products
- Adaptations that allow organisms to overcome the bodies barriers

If the body’s surface is penetrated, the immune system launches an attack to destroy the invading organism. The immune system is a complex organization of cells and proteins that are distributed throughout the body. The function of the immune system is to constantly survey the body for foreign material and eliminate it.

These are the components of the immune system that fight infection:

- **Macrophages:** these cells circulate through the body constantly. Whenever they encounter foreign material, they engulf it through phagocytosis and attempt to destroy it. Whenever a macrophage encounters foreign material it “calls for back-up” by alerting T cells of the invader.

- **T cells:** these cells are very powerful because, once activated, these cells have the power to kill cells in our body that are infected with viruses or bacteria. No other cell in your body has the ability to kill other body cells. Macrophages activate T cells when an intruder has been detected. T cells circulate through the body searching for cells that are infected and kills those cells and the intruder inside them.

- **B cells:** these cells produce antibodies. Antibodies are proteins that recognize foreign material called antigens. When antibodies find foreign material, they bind to it. Many, but not all viruses are inactivated by antibody. When antibody binds to bacteria, it makes it easier for phagocytes to engulf and destroy them. Antibodies are like enzymes in that they only recognize one specific antigen. In order for your body to be effective in neutralizing virus and other foreign material, you body must create billions of different antibodies, each one capable of recognizing a different antigen.

- **Lymph nodes:** lymph nodes are small pea sized structures that are found throughout the body. People often refer to them as “glands”. There are several in the neck region and you may recall your physician palpating them when you feel sick. Lymph nodes are B and T cell storage areas. B and T cells camp out in lymph nodes until an infection occurs. When macrophages detect infection, they alert B and T cells which leave the lymph nodes and travel to the site of the infection through the blood stream.
• **Bone marrow:** this is a very important organ. Bone marrow contains stem cells which are precursors to T cells, B cells and blood cells. Your bone marrow allows you to generate the cells that run your immune system. Bone marrow also allows your body to generate new red blood cells and platelets.

• **Spleen:** the spleen plays two important roles. First, it acts to filter foreign material from your blood. If bacteria, viruses or fungi find their way into you blood stream, the spleen plays an important role at removing these organisms from the blood. The spleen also removes old and dead red blood cells. Second, the spleen acts as a lymph node in that both B and T cells are stored there.

**How come we get sick even though we have an immune system?**

Actually, when you feel sick, it is often because your immune system is working. Fever is an adaptation that our bodies have developed to fight infection. Many bacteria are weakened by higher temperature. Running a fever often helps the immune system defeat bacteria. Painful and swollen glands are also a sign that your immune system is fighting an infection. When an foreign invader is detected, B cells and T cell begin to multiply within lymph nodes—this causes them to swell and we experience the swelling as pain.

Thus many of the symptoms that we have when we are sick are signs that our body is fighting an infection. In most cases, our immune system is able to eliminate the invader and the symptoms go away. This is usually the case with the common cold cause by corona and rhinoviruses. The common cold lasts between three and five days. While the corona and rhinoviruses have developed strategies to penetrate our mucous membranes, our immune system is very good at eliminating the virus and does so in a matter of days.

Unfortunately, our immune systems are not always capable of eliminating an infection by itself. Here are a few reasons why we get infections even though we have immune systems:

- The young and the old typically have weaker immune systems which makes it more difficult for the body to eliminate invaders.
- Certain bacteria, viruses and parasites have adapted so that our immune systems, regardless of how strong they are, cannot eliminate the organism.
- Some people have weakened immune systems because of inherited immune deficiencies or HIV which attacks and destroys T cells.

**How do antibiotics work?**

Antibiotics are drugs that kill or weaken bacteria. Because bacteria are living cells, they must perform many activities to stay alive. They must find nutrients and convert those nutrients into useable energy; they must reproduce; they must synthesize proteins and enzymes to conduct cellular function etc. Each of these activities requires the use of the bacteria’s organelles. Many of the antibiotics that we can use to treat bacterial infections disrupt the function of bacterial organelles. This either results in the bacteria’s death or it weakens the bacteria enough that the immune system can destroy it more easily. Here is a list of common antibiotics that you may be familiar with and their mode of action:

- **Penicillin** damages bacterial cell wall causing rupture and death of bacteria
- **Doxycycline** inhibits bacterial protein synthesis by interfering with bacterial ribosomes
Cipro inhibits bacterial DNA synthesis by interfering with bacterial enzymes.

Can our bodies fight off bacterial infection without antibiotics?
The answer depends on the strength of the person’s immune system and how well the bacteria adapted to evading our immune system. Bacteria such as Mycobacterium tuberculosis (which causes TB) are very well adapted to evading the immune system. People are infected with TB when they inhale droplets of saliva that a person with TB expels when they cough. When Mycobacterium reaches the lungs, it is engulfed by macrophages. In most cases, once a bacteria is engulfed by a macrophage, the macrophage kills it. Mycobacterium have an adaptation that allows them to disarm macrophages so that they can live within a macrophage without being killed and without being noticed by the immune system. Antibiotics are required to eliminate the Mycobacterium from the body.

On the other hand, our bodies can generally fight off ear infections cause by Streptococci. But because there is a small risk of deafness associated with ear infections, most physicians treat ear infections with antibiotics to eliminate that risk. A similar statement can be made for Streptococcal throat infection. Most people with Strep throat infections will recover on their own; however, there is a significant risk of rheumatic fever (a Streptococcus related heart disease) that can result after an untreated strep throat. For this reason, all physicians treat strep throat with antibiotics to prevent the occurrence of rheumatic fever as well as to shorten the length of the infection.

Are there treatments for viruses?
Antibiotics are not effective in treating viruses because viruses do not have the organelles that antibiotics target. Viruses do not have cell walls, ribosomes or enzymes that are targeted by antibiotics.

There are a few limited treatments for viruses. There are two general approaches with antiviral medications. Either the medication targets the virus itself to prevent it from replicating successfully within a cell, or the medication attempts to increase the body’s immune response to the virus.

How do vaccines prevent disease?
The immune system is very clever in that it remembers organisms that it has destroyed in the past so that if that organism returns in the future, it will be able to eliminate it more quickly. This phenomenon is called immunity, or memory. When you got your first cold as a child, macrophages began to ingest the virus and activate T and B cells. Because you had never been ill before, it took a few days for you to recover. Within a few days, your immune system overcame the infection and you got better. Some of the T and B cells that fought the infection became memory B and T cells. Their job is to stay dormant, waiting for that virus to return. If it does, the memory cells will be able to quickly become active and eliminate the virus before you even have a chance to feel sick.

Vaccines work by causing you to develop memory T and B cells against a disease so that if you actually encounter the disease in the future, your memory T and B cells for that disease will be able to fight off the invader quickly and you will not get sick.

Currently there are several vaccines available for many diseases. Chicken pox is caused by a pox virus. As recently as 15 years ago, there was no vaccine for the chicken pox. The only way to become immune was to get the chicken pox yourself. After being infected, memory B and T cells prevent a person from being infected again. Using laboratory techniques, scientists are able to manufacture proteins that are normally found on the surface of the chicken pox virus. By injecting the protein alone without the virus itself, humans develop immunity to the virus. Once the vaccine is
given, macrophages engulf the protein just as they would the real virus. The macrophages notify T
cells just as they would if the real virus was present. Most importantly, memory B and T cells are
generated that protect the person from chicken pox in the future. All of this occurs without the person
becoming ill.

You might wonder: if vaccines are supposed to make you immune to a disease, why do people have
to get the flu vaccine every year? The reason is that from year to year the virus that causes the flu
changes. While this year’s vaccine will protect you from this year’s flu virus, the virus that will be
around next year will probably be different and as a result the memory cells generated with your lasts
vaccine will not be able to recognize the new virus.

**Why don’t humans become immune to the common cold?**
Just like the influenza virus which causes the flu, there are over thirty different corona and
rhinoviruses that cause the common cold. Each cold you get represents a different virus that your
body has not seen. So each time you get a cold, you probably have been infected with a different
virus that you are not yet immune to. The good news is that it is difficult to get the same cold twice,
provided that you maintain your memory cells.

Reading Questions:

Compare a virus to a bacterium:
How are their lifecycle the same or different?
How are the modes of infection the same or different?
Are bacteria and viruses treated the same way?

Use additional resources to answer the following questions. You may use textbooks, appropriate
internet sites and magazine articles to find the answers.

List three viruses for which antiviral medication exists:

_________________
_________________
_________________

Pick two viruses that have treatments. For each virus, state whether the treatment cures the infection,
or not. If the treatment does not cure the infection, explain why the medication fails to cure the
infection.

_________________
_________________
Lab 5: Diagnostic Testing

Introduction:

You probably remember from our first lab, that doctors obtain information about your body and your health by asking you questions and performing a physical exam. Sometimes when we are ill, these techniques do not provide the physician with enough information to determine what is wrong. Fortunately, there are many types of tests that doctors can request that allow them to collect more information about your body. The goal of this lab is to review some of the common procedures and tests that doctors can perform to gather more detailed information about your body. By the end of this session you should understand:

1. What each test is.
2. Why the tests are performed.
3. What the tests allow doctors to see.
4. How the results help doctors create a treatment plan for you.

To help prepare you for the lab, there are three exercises for you:

7. Study the vocabulary below
8. Read the material in this handout about Diagnostic Testing. The reading is designed to answer questions that you might have asked yourself, but never found the answer. Questions such as:
   - What is the difference between a CAT scan and an MRI?
   - What is an Ultrasound?
   - What are doctors looking for when they request “blood work”?
   - What is a biopsy?
9. Complete the questions in the reading.

Vocabulary:

**X-ray:** x-rays are electromagnetic radiation that penetrates human tissue. As the x-rays pass through the body, some of the rays are absorbed while some continue to pass through. The x-ray image is created by allowing the rays that pass through the body to strike a large piece of film. The film is developed in much the same way as a roll of camera film and an image of what is inside the body is produced. Different tissues absorb different amounts of x-rays. For example, bone absorbs the most followed by muscle. Fat absorbs the least. Bone appears white on x-ray, muscle gray and fat dark-gray to black. The advantages of x-rays are that they are quick and inexpensive to obtain. The disadvantages are that they present a two dimensional view of a three dimensional object. Furthermore, x-rays can damage cells. Prolonged or repeated exposure to x-rays can increase a person’s cancer risk.

**CAT scan (also referred to as a “CT”):** (Computer Assisted Tomography) The problem with x-rays is that they make the body appear flat. For example, if you look at a chest x-ray, you see bone, fat, muscle and lung all at once on a flat image. If you did not know that the human body is three dimensional, you would think that all of these structures are on top of each other. A CAT scan uses x-rays to create an image that simulates the three dimensions of the body. A computer uses x-rays to “cut” the body into slices that the doctor can view on a screen. The patient lies in the scanner and the x-rays make slices of the body from head to toe. The advantage of CAT scans over x-rays is that they provide more detailed information. The disadvantages are they are more expensive than regular x-rays and they expose the patient to a larger dose of radiation.
As the patient passes through the scanner, x-ray images (“slices”) are taken at each level of the body.

This diagram shows what slices of different parts of the body would look like.

**MRI:** (Magnetic Resonance Imaging) This tool is similar to CAT scans in that MRIs also create slices of the human body. The major difference is that MRI uses a magnetic field to obtain the image instead of x-rays. The advantages of using a magnetic field are:

1. MRI creates a higher resolution image compared to CT
2. Unlike x-rays, the magnetic field used is not harmful in anyway
3. MRI creates superior images of soft tissues such as muscle, brain, tendons and ligaments.

There are several disadvantages to MRI. MRIs are much more expensive compared to CAT scans. They also take much longer to make. A CAT scan can be performed in a few seconds whereas an MRI usually takes around twenty minutes. While this might not sound like a lot
of time, it can make all the difference in a patient who is critically ill (for example a stroke victim or a person in a motor vehicle accident).

**Mammogram:** A specific type of x-ray designed to evaluate breast tissue. To perform a mammogram, the patient’s breast is held between two plastic plates. The plastic plates apply gentle pressure to the breast to spread the breast tissue out which allows for a higher quality image. The x-ray is taken through the plastic plates. Mammograms are important in adult women because they help doctors identify lumps that might not be felt on a manual breast exam.

**Ultrasound:** This tool uses sonic waves (high frequency sound not audible to the human ear) to create an image. A probe that emits sonic energy is placed on the surface of the body. The waves penetrate the body and bounce off of the structures inside creating an “echo” that the returns to the probe. A computer connected to the probe analyzes the echo and converts the sound into an image that the doctor can view. The way ultrasound works is very similar to the way bats use high pitched sound to “see” in the dark. The advantages to ultrasound are that it is inexpensive and it does not use harmful radiation. In addition, an ultrasound can be performed in a patient’s room or a doctor’s office with a portable device. Most importantly, ultrasound creates a “live” image. This is valuable when looking at structures like the heart which have valves and other structures that move. Fetal ultrasound allows doctors to observe a living fetus without exposing it to any harmful radiation.

**Angiogram:** Under normal circumstances, blood vessels are not clearly visible using x-rays. An angiogram is a tool that allows doctors to use x-rays to view vessels. To perform an angiogram, the doctor injects a blood vessel with a dye that is visible by x-ray. While the dye is being injected, an x-ray image is taken. Because the vessel is filled with dye while the x-ray is taken, the vessel will be visible to the doctor on the image. Angiograms are helpful in determining whether an artery is blocked with plaque. Patients who are suspected of having a heart attack often have a coronary angiogram to determine if the coronary arteries that supply the heart are blocked with plaque. A similar test can be performed on patients with stroke to determine if the arteries supplying the brain are blocked.

The advantages of this test are that it provides direct evidence of arterial blockage and it can be performed relatively quickly. The disadvantages are that angiograms cannot be performed in a patient’s room—they typically must be performed in a surgical setting. Some patients can have an allergic reaction to the dye. Other patients with unhealthy kidneys can experiences further deterioration of their kidney function due to the effects of the dye.

**Stress test:** This tool is used to test the heart function in a patient who is suspected of having heart disease. A stress test helps identify patients who are at risk of having a heart attack before it happens. This gives the doctor and patient time to make necessary changes to prevent a heart attack. To perform a stress test, the patient is fitted with EKG leads on his or her chest. The patient is then asked to walk on a treadmill while the doctor observes the patient’s EKG on a screen. Gradually, the speed and the incline on the treadmill increases and the doctor observes the patient’s response to the increased physical “stress”. If the heart’s response is abnormal, the test is stopped. An abnormal stress test gives doctors a warning that the patient may have heart disease and provides an opportunity for physicians and patients to address these problems before they get worse.

**Biopsy:** This tool allows doctors to examine suspicious growths to determine if they are cancerous. Instead of a major operation to remove the entire growth, a small incision is made and a small piece of the suspicious tissue is removed and sent to a lab for investigation. If the result
shows normal tissue, the patient was spared a major surgery. If the report shows a harmful cancer, doctors can determine the best treatment plan based on the type of cancer. Some are cured best with surgical removal while others respond better to chemotherapy or radiation. Still others respond best to a combination of two or more of these approaches.
**X-Ray Images**

X-ray images are generated by directing x-rays though the body part to be examined. A piece of film is placed on the other side of the body part to record the x-rays that succeed in passing through the body part. In the picture below, the patient’s hand is being x-rayed. The x-rays are being projected from above. The film is contained inside the plate below the patient’s hand.

Can you find the fracture(s) in the x-ray?

Are the fractures in the fingers, palm or wrist? __________________________________________________________________________

Which bone(s) of the hand is/are fractured? __________________________________________________________________________

X-rays are helpful in detecting more than just bone fractures. Below are common types of x-rays and the disease they can help find:

- Chest x-ray
- Pneumonia
- Collapsed lung
- Emphysema
- Lung cancer
- Tuberculosis
- Heart failure
- Aortic aneurism
Abdominal x-ray  Constipation
    Irritable Bowel Disease
    Colon cancer
    Rupture of digestive tract
    Kidney stone

Who gets an x-ray?
Because excessive exposure to x-rays can be harmful, there needs to be a good reason for a doctor to request an x-ray.

X-rays are usually ordered to help diagnose a disease when the diagnosis isn’t clear after physical exam.

Example:
An elderly patient visits the doctor with a cough and a fever. The doctor examines the patient and the lung exam suggests the presence of pneumonia. To confirm the diagnosis and to determine if the pneumonia is severe enough to require antibiotics, the doctor orders a chest x-ray.

![Chest X-ray](image)

Normal

The normal x-ray is on the right for comparison.

Can you spot the pneumonia on the chest x-ray above?

Which lung is the pneumonia in?  ____________________

Which lobe is the pneumonia in?  ____________________
CAT scan and MRI

CAT scans are useful when an x-ray cannot give the detailed information needed to find the problem. CT scans have an added advantage over MRI in an emergency because CT images are generated several times faster than MRI.

Example:

An eighteen year old pitcher is struck in the head by a baseball. He briefly lost consciousness but is now awake in the emergency room complaining of a severe headache.

A CAT scan of the patient's head is performed. A section from the CT is shown above. The CT image shows a hemorrhage (bleeding into the brain).

Can you find the hemorrhage?

Which side of the brain is it on? _______________________

Why didn’t the doctors order an MRI? __________________________

Why didn’t the doctors order an x-ray? __________________________

Example:
A thirty five year old woman goes to her doctor complaining of multiple symptoms including double vision, weakness in her arms and trouble walking. The woman does not appear to be in any immediate danger, but she is quite worried about her symptoms which have gotten progressively worse over the past week. She had a friend drive her to the doctor’s office because she was afraid that her double vision would lead to an accident. The physician suspects MS (multiple sclerosis) and orders an MRI of her brain. A section of the MRI is shown below.

**Notice the increased detail in the MRI compared to the CT scan of the previous patient. The most noticeable improvement is the ability to easily differentiate between grey matter and white matter in the MRI compared to the CT.**

Can you find the lesions that are suggestive of MS?

Which lobe(s) of the brain is/are the lesion(s)? ____________________________

What part of the nervous system does MS affect? ____________________________

Is there a cure for MS? ____________________________

Why did the physician choose to order a MRI instead of a CT? _______________________
____________________________________________________________________

**Blood Tests**

Physicians can learn a substantial amount about the health of your body by measuring certain substances in your blood. The are three major purposes of blood tests:

1. Check for anemia
2. Check electrolyte balance
3. Search for infection

Beyond these tests there are many more, some of which we have already talked about (cholesterol tests, glucose tests).

*Standard blood test (Complete Blood Count plus Electrolytes)*
A typical blood test contains a red blood cell count, a white blood cell count, and an electrolyte measurement. Doctors may order this test occasionally in a health person to make sure that there are no hidden problems that were missed on physical exam.

A low red blood cell count would suggest an anemia. There are many causes of anemia. A few of them are:

1. Iron deficiency
2. Vitamin deficiency (particularly vitamins B12, thiamine and folate)
3. Inherited anemia such as thalassemia and sickle cell anemia

A high white blood cell count would suggest that the body is fighting off an infection. If the source is not apparent from physical exam, the source should be sought.

The electrolyte measurement assesses the concentration of important ions in the body. Normal concentrations of these ions are necessary to maintain an isotonic environment suitable for our cells. If electrolyte levels fall, our blood becomes hypotonic which can cause our cells to function abnormally as they begin to swell. If our electrolyte levels are too high, cell dysfunction can occur as fluid is leached from cells. The most common signs of electrolyte disturbance are muscle weakness and confusion. If uncorrected, the problem can evolve to include heart arrhythmia, seizure and coma. Electrolyte disturbances can occur as a result of fluid loss (primarily through sweat) during periods of strenuous exercise without adequate fluid replacement. Electrolyte disturbance is also a dangerous consequence of uncontrolled diabetes. Below is a list of the most important electrolytes and their normal concentration in our blood. Don’t memorize the list!

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Concentration in millimoles/liter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na+</td>
<td>135 - 145</td>
</tr>
<tr>
<td>K+</td>
<td>3.4 - 4.9</td>
</tr>
<tr>
<td>Cl-</td>
<td>97 - 110</td>
</tr>
<tr>
<td>HCO3-</td>
<td>23 - 24 (bicarbonate)</td>
</tr>
<tr>
<td>Ca2+</td>
<td>8.6 – 10.3</td>
</tr>
<tr>
<td>Mg2+</td>
<td>1.3 – 2.2</td>
</tr>
<tr>
<td>PO4 3-</td>
<td>0.81 – 1.45</td>
</tr>
</tbody>
</table>

**HIV testing**

Regular HIV testing, along with other STD tests, is now recommended as part of the normal care of sexually active individuals. An HIV test is a blood test performed separately from other blood tests. While a physician may recommend that a person be tested for HIV, the test cannot be performed without the patient’s informed consent.

The most common test for HIV checks for antibodies against HIV in a patient’s blood sample. Normally, people who have not been infected with HIV will not have antibodies against HIV. Within three weeks to three months of infection, patients with HIV will produce antibodies against the virus that can be detected by the test. Because of the lag time between infection and antibody production, testing is not helpful until at least three months after a suspected HIV exposure.

All positive antibody HIV tests are double checked with a second test that searches for HIV RNA in a patient’s blood sample. Double checking is important to prevent “false alarms”.

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Urine Tests
Similar to blood tests, urine tests help doctors learn more about the health of your body. Urine tests are helpful in the following ways:

1. Assess kidney function
2. Find cause of electrolyte disturbance
3. Test for Urinary Tract Infection (UTI)
4. Test for STDs

Because urine is produced by the kidney, it is obvious that urine testing can be helpful in assessing the health of a patient’s kidneys. Urine testing is also used to confirm the diagnosis if UTI. Doctors can generally diagnose UTI from information they get from the patient and during a physical exam. A urine sample is usually collected to make sure that the antibiotics prescribed will eliminate the bacteria that caused the infection.

Urine testing is also helpful in diagnosing gonorrhea and Chlamydia infections.
Lab 6: Measuring Daily Calorie Expenditure

Introduction:
During Lab 2 you recorded your daily caloric intake over a period of five days. You may remember that knowing your daily caloric intake is more valuable when you can compare that value to your daily caloric expenditure (the number of calories you burn each day). In this lab, you will learn how to estimate the number of calories you burn in a day. You will compare your daily calorie expenditure to your caloric intake and determine whether your present nutrition and exercise habits achieve a healthy balance.

You may want to review the material in Lab 3 which explains what metabolism is and how your body converts food into usable energy. Lab 3 also explains how your body stores excess energy for later use.

Procedure:
1. Read the lab handout.
2. Wear Pedometer for five consecutive days (while awake) and record the total number of steps taken each day on the Data chart found on the next page. Be sure to reset the pedometer at the beginning of each day.
3. Estimate RMR using the Guide on pages 2 through 4. Record the RMR on the Data chart. The RMR is the same for all five days.
4. Estimate the Thermic Effect of Activity for each day using the guide on pages 4 through 6. Record your estimates on the Data chart.
5. Estimate the Thermic Effect of Feeding for each day using the guide of pages 6 and 7. Record your estimates on the Data chart.
6. Calculate your daily Total Energy expenditure by summing your RMR, Thermic Effect of Activity and Thermic Effect of Feeding for each day.

Vocabulary:
Food calorie: unit of energy equivalent to 1 kilocalorie. A kilocalorie is defined as the amount of energy required to raise the temperature of 1 liter of water by one degree Celsius.

Resting Metabolic Rate: the number of calories the body uses passively; for example, calories used to maintain body temp, conduct ventilation, pump blood etc.

Thermic Effect of Feeding: the calories spent to digest food.

Thermic Effect of Activity: calories spent doing voluntary activities; for example, walking, running, fidgeting.
**Total Energy Expenditure**: the total number of calories spent each day; that is, the sum of Resting Metabolic Rate, Thermic Effect of Feeding, and Thermic Effect of Activity.

**Your daily calorie expenditure is the sum of three calorie burning activities.**
In Lab 3 we stated that Total Energy Expenditure is the total number of calories that a person burns a day. Three calorie burning activities contribute to your Total Energy Expenditure and they are:
- Resting Metabolic Rate
- Thermic Effect of Feeding
- Thermic Effect of Activity

Thus:

\[ \text{~60\%} \quad \text{~15-30\%} \quad \text{~10\%} \]

\[ \text{Total Energy Expenditure} = \text{Resting Metabolic Rate} + \text{Thermic Effect of Activity} + \text{Thermic Effect of Feeding} \]

**Estimating Resting Metabolic rate, Thermic Effect of Feeding and Thermic Effect of Activity.**
When our bodies use energy we generate heat. This is why we are “warm blooded”. Anyone who has ever exercised knows that the more you exercise, the more heat your body generates and the harder your body has to work to get rid of the heat (sweating, skin flushing and your desire to jump in a pool or drink cold water etc). To accurately measure a person’s Total Energy Expenditure it would be necessary to continuously measure the amount of heat that the person’s body gives off over twenty four hours. The amount of heat that a person’s body gives off is directly related to how much energy (calories) that person has used. A calorimeter is the instrument used to measure the amount of heat that an object gives off. If you have taken advanced Chemistry or Physics, you may have made a calorimeter to measure the heat of small reactions using Styrofoam coffee cups and a thermometer. To accurately measure a person’s total energy expenditure, a human sized calorimeter is necessary. Unfortunately, such large calorimeters are remarkably expensive and very inconvenient for the person being monitored, as they have to remain in the calorimeter for an entire day.

Instead of using a human calorimeter to measure Total Energy Expenditure, you will estimate your Resting Metabolic rate, Thermic Effect of Feeding and Thermic Effect of Activity using the charts in this handout and your pedometer.

**Estimating Resting Metabolic Rate (RMR)**
The Resting Metabolic Rate (RMR) is the energy that your body consumes while at rest. This energy is used by your heart, your diaphragm and other muscles that are constantly working to keep you alive. Your brain also uses energy while at rest and this energy is included in the Resting Metabolic Rate.

An accurate way to measure RMR is to observe how much heat a person gives off while at rest using a calorimeter. Researchers noticed that there is a proportional relationship between a person’s surface area and their RMR. They noticed that as a person’s surface area increases, so does their Resting Metabolic Rate. This makes sense because the larger a person is, the more energy is required to pump blood through a larger body, the more energy is required to breathe more air etc. Therefore, if a person knows his or her surface area, he or she can estimate his or her Resting Metabolic Rate.
Unfortunately, most people don’t know, off-hand, what their surface area is. Luckily, surface area can be estimated from your height and weight. The chart below can be used to estimate your surface area.

To use the chart, first locate your height on Scale I and your weight on Scale II. Next, draw a line with a ruler connecting the two points. The point where the line crosses Scale III is your surface area. (Taken from McArdle’s Essentials of Exercise Physiology, 2nd Edition, 2000)

Your Height (ft, in): ______________

Your Weight (lbs):   ______________

Corresponding Surface area (m²): ______________

Now that know your surface area, we can take the next step and use your surface area to estimate your Resting Metabolic Rate. Researchers using human calorimeters made the following observation after measuring the Resting Metabolic Rate of several people of different sizes:

While at rest, a 17 year old male, will expend 40 kcal each hour for every square meter of body surface area while at rest.

While at rest, a 17 year old female, will expend 37 kcal each hour for every square meter of body surface area while at rest.

In other words:
RMR males: 40 kcal per m² per hour
RMR females: 37 kcal per m² per hour
Thus your RMR per hour equals your surface area times the appropriate hourly RMR (40 for males or 37 for females. Your RMR for and entire day is equal to your hourly RMR times 24 since there are 24 hours in a day. This can be stated mathematically with the following equation:

Males:
\[ \text{RMR in one day} = 40 \text{ kcal/ m}^2 \text{ hour} \times \text{surface area (m}^2) \times 24 \text{ hours/day} \]

Females:
\[ \text{RMR in one day} = 37 \text{ kcal/ m}^2 \text{ hour} \times \text{surface area (m}^2) \times 24 \text{ hours/day} \]

Using the appropriate equation, calculate your daily RMR:

**Daily RMR:** _______________

You may be wondering why females burn fewer calories per hour while at rest compared to males. The reason is that normal females have a lower muscle to fat ratio compared to males. In other words, if you compared a man and a woman who weighed the same, the woman would have more fat and less muscle than the man. Muscle is primarily responsible for consuming energy while at rest. Therefore, if the female has less muscle than a man of the same weight, she will consume less calories while at rest than the man.

**Estimating Thermic Effect of Activity**

The Thermic Effect of Activity is the amount of energy consumed by voluntary activities. This includes not just exercise, but all activities that you perform including scratching your head, writing and playing video games. An accurate method of measuring the thermic Effect of Activity is to use a calorimeter to measure the amount of heat that the subject releases while performing an activity such as running on a treadmill.

Because we are not using human calorimeters, we need to find a simpler way to estimate the Thermic Effect of Activity. Moving your body from place to place is likely the most significant contributor to your Thermic Effect of Activity. While you burn a few calories each day scratching your head, this amount of energy is very small compared to the amount of energy you burn walking from class to class, participating in sports etc. Therefore, if we keep track of your movement using a pedometer we can estimate your Thermic Effect of Activity, keeping in mind that our estimate will be slightly lower than the actual value because we are choosing to ignore the calories you spent scratching your head, brushing your teeth and so on.

The pedometer measures the number of steps you take by detecting the impact created by your feet and the ground each time you take a step. In general, the more steps you take each day the greater your Thermic Effect of Activity. There are several factors that determine how many calories you burn while walking:

- **Number of steps taken:** This information will be provided by your pedometer. Obviously, the more steps you take the more calories you burn.

- **Distance walked:** Researchers have determined how many calories are consumed by walking a mile. Therefore, you will have to calculate how many miles you have walked in a day from the number of steps you have taken. The easiest way to do this is to determine the average length of each step you take. Then you multiply the number of steps you have taken in a day by the average length per step:
Distance walked = Steps x Distance per step

**Weight:** Your weight affects how many calories you burn per mile of walking. The heavier a person is, the more calories he burns per mile. Moving your body is work. Therefore, the heavier a body is, the more work is performed to move it and the greater the calorie expenditure to perform that work.

**Speed:** The faster you walk, the greater your calorie consumption per mile. If you double the speed at which you walk, you double the rate at which you burn calories. While there are pedometers that record your walking speed, we will assume that you walk at an average speed of 4 miles per hour.

**Gradient:** The gradient of the surface you are walking on affects the amount of calories that you expend. For example, walking uphill uses more calories that walking on a level surface. We will assume that you are walking on a flat surface, knowing that our estimate of calories expended while walking will be lower than the actual value because of this assumption.

**Measuring your gait**

While in class you will measure the distance between your feet when you take a step. Once you know how long each of your steps is, you will calculate how many steps you must take in order to walk a mile. Knowing this information will allow you to determine how many miles you’ve walked in a day from the number of steps recorded by your pedometer.

You will pair up with a classmate who will help you measure your gait at the gait measuring station. The station consists of a paper runway that is fixed to the floor. There will be a marker to mark the distance between your feet when you take a step and a yardstick to measure the distance between the two marks.

An accurate way to measure your gait is to begin walking on the runway at a normal pace. Before you reach the end of the runway, you should freeze in mid step so that your partner can make a mark on the runway behind each of your heels. Once your partner has made the marks, move away and use the yardstick to measure the distance between the marks. **Record the distance in inches.** Repeat the process two more times but at different walking speeds and average the three distances.

1st Gait Measurement: ______ inches
2nd Gait Measurement: ______ inches
3rd Gait Measurement: ______ inches

**Average Gait Length:** ______ inches

**Calculating steps per mile**

Now that you know your average gait length, you can calculate how many steps you must take to walk a mile.

One mile = 5,280 feet.

Multiplying by twelve converts this distance to inches:

One mile = 63,360 inches

Steps per mile = 63,360 inches ÷ Average Gait Length (in inches)
Steps per mile: ______

Estimating Thermic Effect of Activity using a Web Calculator

Now you are ready to calculate your daily Thermic Effect of Activity. At the end of each day, record the total number of steps you have taken from your pedometer.

After recording your steps for five days, visit the link below:


First select your weight. The menu offers weights in 20 pound intervals. Select the weight that is closest to your actual weight. Next, set the pace to 3 miles per hour. Then enter the number of steps you walked on the first day. In the space provided, enter the steps per mile that you calculated above. Click on the “Calculate It!” button. Record the number of calories you expended. Repeat the process for each day.

Thermic Effect of Activity

Day 1: ______ kcal
Day 2: ______ kcal
Day 3: ______ kcal
Day 4: ______ kcal
Day 5: ______ kcal

Estimating Thermic Effect of Feeding

Thermic Effect of Feeding is the amount of energy your body uses each day to digest the food that you eat. Peristalsis, the production of bile, stomach acids and enzymes all require energy. The amount of energy that is required for digestion varies with the amount and type of food that you eat. As a general rule, however the Thermic Effect of Feeding is approximately 10% of your total caloric expenditure. We will use this approximation to estimate your daily Thermic Effect of Feeding.

Remember:

Total Energy Expenditure = Resting Metabolic Rate + Thermic Effect of Feeding + Thermic effect of activity

If the Thermic Effect of Feeding is equivalent to 10% of the Total Energy Expenditure, then the sum of the Resting Metabolic Rate and the Thermic Effect of Activity is equal to 90% of the Total Energy Expenditure. Because we have calculated the Resting Metabolic Rate and the Thermic Effect of Activity, we can use algebra to calculate the Thermic Effect of Feeding.

Let Resting Metabolic Rate + Thermic Effect of Activity = 9x (90%)
Then Let Thermic Effect of Feeding = x (10%)

Using your estimates for Resting Metabolic Rate and Thermic Effect of Activity, solve for x.

Thermic Effect of Feeding

Day 1: _____ kcal
Day 2: _____ kcal
Day 3: _____ kcal
Day 4: _____ kcal
Day 5: _____ kcal
Name: _______________________

## Data Chart

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<th>Steps</th>
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<th>Thermic Effect of Feeding</th>
<th>Total Energy Expenditure</th>
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Each day, record the number of steps you have taken.

Using the handout, calculate your daily RMR, Thermic Effect of Activity and Thermic Effect of Feeding. Record these daily values in the appropriate box.

For each day, calculate your Total Energy Expenditure by adding the appropriate values.

**Total Energy Expenditure = RMR + Thermic Effect of Activity + Thermic Effect of Feeding**