AUGUSTA UNIVERSITY
MEDICAL COLLEGE OF GEORGIA

Department of Physiology

PHYSIOLOGY

Graduate Student Handbook

2021

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A. GENERAL INFORMATION

A1. Department of Physiology Location

1410 Laney Walker Blvd, Interdisciplinary Research Building (CA), 1st, 2nd & 3rd Floor
1456 Laney Walker Blvd, Carl T. Sanders R & E Building (CB), 2nd Floor

A2. Department of Physiology Phone Numbers

Department Chair:	David Mattson, PhD	706-721-4479
Program Director:	Yisang Yoon, PhD	706-721-7859
Department Manager:	Cathy Davidson	706-721-7739
Administrative Support:	Melanie Gee	706-721-4411
	Shane Harper	706-721-0784
	Kara MacVean, MBA	706-721-7735

A3. Important Campus Phone Numbers

Academic Admissions	706-721-2725
Cashier's Office	706-721-2926
Financial Aid Office	706-721-4901
Graduate Studies Office	706-721-3278
Housing Office	706-721-3471
Registrar's Office	706-721-2201
Student Affairs	706-721-3356
Student Health	706-721-3448
Public Safety	706-721-2911
Housekeeping	706-721-2040
Chemical Safety	706-721-2591
Radiation Safety	706-721-9826
Information Technology	706-721-4000
MCG Workshop	706-721-2040
Laboratory for Animal Services	706-721-3421
Flow Cytometry	706-721-7323
Fisher Room	706-721-0601
BioRad	706-721-7670
Sigma	706-721-0601

A4. Augusta University (AU) on the Web

AU Home page: http://www.augusta.edu
Physiology: http://www.augusta.edu/mcg/phy/index.php
The Graduate School (TGS): http://www.augusta.edu/gradstudies/index.php

B. GRADUATE PROGRAM IN PHYSIOLOGY

B1. Mission Statement:

The mission of the Graduate Program in the Department of Physiology at the Medical College of Georgia is to provide graduate level research scientists with the necessary didactic training, problem solving, communication, and professional skills necessary to become future leaders in research and education. These skills are developed through state of the art laboratory research in a broad spectrum of experimental systems from molecules to whole body physiology and pathophysiology.

B2. Short overview of the program:

The Department of Physiology trains graduate students under the auspices of the Biomedical Sciences Program in the Graduate School (TGS) at the Augusta University leading to a PhD degree in Physiology. An MD/PhD or DMD/PhD degree program is also available. The department houses faculty with complementary interests and successful collaborations. Every year, new graduate students join the program after the completion of their first year in the umbrella program in Biomedical Sciences.

Our program emphasizes an integrative approach to physiology, with expertise in molecular, cellular, and organismal research methods offering students a true interdisciplinary training opportunity. Faculty members are active and hold leadership positions in several national organizations including the American Physiological Society (APS), the American Heart Association (AHA) and the Endocrine Society as well as National Institutes of Health (NIH) where they chair or serve on committees and review groups. They share their experience in grant proposal preparation with students in the Scientific Grant Writing course. Students have a high success rate in securing predoctoral grants and oral/poster presentations at national meetings.

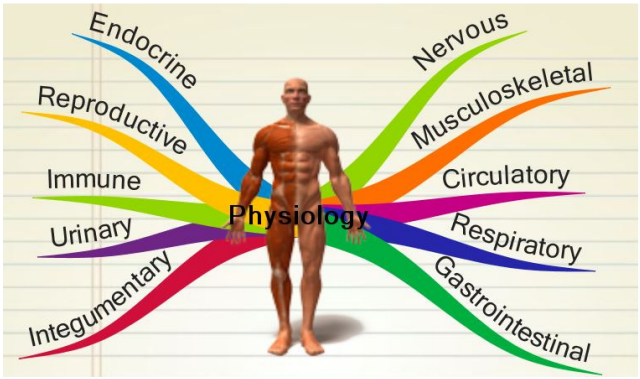
B3. Program goals and objectives:

a. Train independent, creative, and productive scholars in the physiological sciences

b. Strive to prepare students for successful careers spanning academia, government and industry

B4. Why Physiology Program? *Physiology expands our understanding of…*

- What "life" is
- How life processes work and are regulated
- Diseases and how to treat them
- How living organisms cope with or adapt to different environments
- Physiology represents intersection of numerous disciplines



Program Highlights:

Research Focus: High impact translational research in physiology and pathophysiology of organs and organisms

Trainee Grants: Numerous American Heart Association and NIH Predoctoral Fellowships have been received by our trainees and we have one of the most trainee-funded programs at Augusta University.

Faculty: Internationally recognized faculty in their respective disciplines.

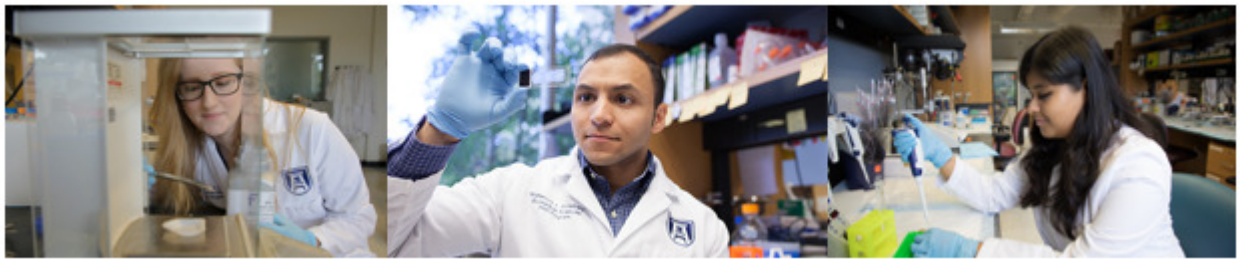
Publications: An average of 3 first author publications by graduation.

Training Environment: A well-balanced mix of graduate students, postdoctoral fellows, junior faculty and senior faculty in highly collaborative laboratories.

Service Commitment: Involvement of trainees and faculty in community outreach such as PhUN week at local schools and local activities for the homeless.

Awards: Our students are recipients of many national and international awards such as American Physiological Society (APS) Caroline tum Suden/Francis Hellebrandt Professional Opportunity Award; American Heart Association Council on Hypertension, Young Investigator Award; International Society of Hypertension, Best Oral Presentation Award.

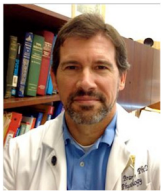
Our Trainees: 90% of our graduates move to postdoctoral positions in highly reputable research institutions such as Harvard University, University of Michigan, and UCLA.



B5. The Faculty Research:

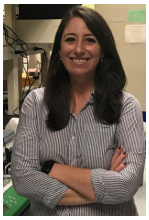
Zsolt Bagi, MD, PhD: Professor, General Semmelweis University of Budap**,** 2004. Coronary microvascular disease in patients with diabetes mellitus and diastolic heart failure. zbagi@augusta.edu

Wendy Bollag, PhD: Professor, Yale University**,** 1990. Adrenal steroid synthesis and ACTH signaling. wbollag@augusta.edu



Michael Brands, PhD: Regents' Professor, University of Missouri, 1988. Integrative cardio-renal physiology in diabetes and inflammation. Roles of insulin and renin-angiotensin-aldosterone system. mbrands@augusta.edu

Weiqin Chen, PhD: Associate Professor, Michigan State University, 2005. Players that mediate adipose tissue development and how the dysfunction of adipose tissue causes metabolic diseases under obesity and lipodystrophy. wechen@augusta.edu



Jessica Faulkner, PhD: Assistant Professor, University of Mississippi Medical Center, 2015. Mechanisms of high blood pressure, vascular damage and fetal growth restriction in obese and lean pregnancy. jefaulkner@augusta.edu

Jessica Filosa, PhD: Professor, signalling mechanisms governing bi-directional communication among the various cell types within the brain, neurovascular coupling. jfilosa@augusta.edu

Daria Ilatovskaya, PhD: Associate Professor, Institute of Cytology, Russian Academy of Sciences, 2012. Water and electrolyte homeostasis, mitochondrial bioenergetics, regulation of ion channel function and their role in the development of cardiorenal pathologies, such as hypertension and polycystic kidney disease, and sex-related differences in these conditions. DILATOVSKAYA@augusta.edu

Ruth Harris, PhD: Regents' Professor, University of Leeds, 1981. Leptin signaling in the control of food intake and stress responses. ruharris@augusta.edu

Mykola Mamenko, PhD: Assistant Professor, Bogomoletz Institute of Physiology, 2007. Establishing the contribution of intracellular calcium signaling in renal epithelial cells into water and electrolyte handling by the kidney and at revealing novel mechanisms associated with PKD and NDI. mmamenko@augusta.edu

David Mattson, PhD: Department Chair and Professor, Medical College of Wisconsin, 1990. Studies in the Mattson laboratory examine the normal and pathophysiological regulation of renal function and arterial blood pressure. dmattson@augusta.edu

Paul M. O'Connor, PhD: Professor, Monash University, 2005. Voltage-gated proton channel physiology and pathophysiology. paoconnor@augusta.edu

Philip O'Herron, PhD: Research Assistant Professor, Johns Hopkins University, 2009. Neurovascular coupling; the mechanisms and the functional role of the overshoot of blood supply in functional hyperemia. poherron@augusta.edu

Jennifer C. Sullivan, PhD: Interim Dean of the Graduate School, Professor, Albany Medical College, 2010. Sex differences in cardiovascular and renal diseases. jensullivan@augusta.edu

Mong Wang, PhD: Associate Professor, Rutgers University, 1995. Eicosanoids in the regulation of renal function and blood pressure, role of renal tubular 20-HETE and EETs on sodium retention in obese rats, renal EET biosynthesis in pregnancy. mwang@augusta.edu

Yisang Yoon, PhD: Professor, Ohio State University, 1993. Molecular mechanisms of mitochondrial shape change and to understand physiological significance of mitochondrial dynamics. yyoon@augusta.edu

B6. Overview of the organizational structure of the Program:

Dr. David Mattson, Department Chair, oversees the graduate program with the departmental Program Director, Dr. Yisang Yoon. They also serve on the Physiology Department Graduate Education Committee with Drs. Wendy Bollag, Jessica Filosa, and Mykola Mamenko, and a student representative. The Program is run with the assistance of departmental staff and in consultation with the office of the Dean in the Graduate School.

C. PHYSIOLOGY PROGRAM CURRICULUM

The Doctor of Philosophy degree is not "lock-step" and thus students do not graduate as a class at the end of a specific semester. The average time to degree is approximately 5 years of full-time, year-round study; with the acceptable duration of the program being between 3-7 years. The PhD curriculum is individualized based on input of the Advisory Committee of the student.

C1. Milestones by the year:

YEAR 1. Core curriculum in Biomedical Sciences Program

YEAR 2. After identifying a mentor and joining the Program in Physiology, students are expected to learn and comprehend the primary literature relevant to mentor's research and should gain first-hand expertise in methodologies used in the laboratory.

Courses: Students should enroll in PSIO 9210 Investigation of a Problem for all semesters including Summer, and PSIO 9010 Seminar for Fall and Spring semesters. Students should also sign up for BIOM 8130 Scientific Grant Writing in the Fall semester, which is the only required course in the program. Students should have a minimum 5 credit hours of advanced level courses in the program. This 1 credit hour course (BIOM 8130) counts towards advanced credits. Remaining advance level courses can be any combination of the courses listed below under coursework or courses from the TGS catalogue if the advisor and committee approve. Students are encouraged to enroll in PSIO 8315 Teaching Practicum in Physiology (2 credit hours) in the Spring semester, which involves tutoring first year Biomedical PhD students in Systems Biology. This enables the students to review their knowledge in Physiology and helps them in preparation for the comprehensive exam.

Students are encouraged to form their advisory committee within the first six months after they join the mentor's laboratory and have the first committee meeting within their first year (end of 6th semester in the Biomedical Program). Once the advisory committee is formed, students are required to submit the coursework proposal by the end of 5th semester. It is a mandatory TGS requirement that the student convenes at least one official (documented) committee meeting within an academic year. Committee members evaluate the student's performance by completing a committee meeting rubric (a copy is at the end of this handbook). Students and mentors are encouraged to look at this rubric to guide the preparation of student's presentation to the committee. The establishment of committee is important because students are expected to complete their comprehensive exam by the end of 7th semester. During this first year in the program, students should be working toward the preparation of their comprehensive examination.

YEAR 3. Students are expected to take and pass the written and oral sections of the qualifying exam by the end of 7th semester, which marks the first semester in year 2 after they join the Physiology Program. They are highly encouraged to complete the exam as early as possible.
The third year should focus on experiments that will form the basis of their research proposal and a predoctoral fellowship application.

Courses: Students should enroll in PSIO 9210 Investigation of a Problem for all semesters including Summer, and PSIO 9010 Seminar for Fall and Spring semesters. Although students should successfully complete their qualifying exam by this time, they can still take courses if they or their committees choose to do so.
TGS mandates that the research proposal must be completed by the end of the second year in the Physiology Program (9th semester after matriculation). Committee members evaluate the

student's performance by completing a research proposal rubric (a copy is at the end of this handbook). Students and mentors are encouraged to look at this rubric to guide the preparation of student's research proposal and presentation to the committee. Once the qualifying exam and the research proposal requirements are completed and approved by the Committee, the students are then officially admitted to PhD candidacy.

YEAR 4. Effort in fourth year will mainly involve carrying out the proposed research and publishing results where possible.

Courses: Students should enroll in PSIO 9300 Research (This replaces PSIO 9210 once the student is officially admitted to candidacy) and PSIO 9010 Seminar for both Fall and Spring semesters.

YEAR 5. Students in the fourth year of the Physiology Program (5th year at AU) work towards completion of experimental work while preparing their thesis, which on average is defended by the end of the year. During this final year (on average), students should also be considering post-graduation plans, such as identification of a post-doctoral position.

Year	*Major milestones*	*Expectations/ Responsibility*
1 F Sp Su **Core curriculum Rotations**	**Choose major advisor**	
2 F Sp Su **BIOM 8130** — **PSIO 8315** **PSIO 9010** **PSIO 9210** **Any elective course**	**Establish Advisory Committee** **Obtain Advisory Committee approval for coursework**	**Master research techniques** **Progress report at the end of every semester** **Advisory Committee meeting during any semester in the academic year.**
3 F Sp Su **PSIO 9010** **PSIO 9210** **Any elective course** **Comprehen -sive exam** — **Research proposal**	**Comprehensive exam to be successfully completed by the end of Fall semester the latest** **Complete research proposal**	**Passing grade on written and oral exam** **Advisory Committee meeting during any semester in the academic year** **Experiments with the guidance of the Advisory Committee and Mentor**
4 F Sp Su **PSIO 9010** **PSIO 9300**	**First paper**	
5 F Sp Su **PSIO 9010** **PSIO 9300**	**Prepare Dissertation Papers**	**Write your thesis in accordance with COG's guidelines** **Defend**

C2. The Advisory Committee:

C2.1 Major Advisor

The major advisor, also designated as mentor, chosen by the student has to be a faculty member in the Physiology Program. The major advisor's responsibilities include training the students as well as providing the financial and technical support the student's needs toward successful completion of her/his project. The advisor also helps with writing grant proposal, manuscripts and preparing presentations. The major advisor should also be instrumental in helping the student to choose and interact with the advisory committee and to prepare them for the thesis defense. It is not the responsibility of the major advisor to ensure that the student maintains good standing with TGS by arranging for committee meetings or ensuring that the appropriate paperwork is submitted to the TGS in a timely manner. These latter administrative functions are the responsibility of the student in consultation with the program director.

C2.2 Other Committee Members

The advisory committee includes 5 members (mentor and 4 members). At least four of the five members (including major advisor) must hold appointments on the faculty of TGS. Students are encouraged to have at least one clinician faculty. Exceptions will be granted by the Program Director if identifying a clinician committee member prevents student from moving forward. It is also recommended that 2 of the 4 also be Physiology faculty in order to facilitate the proceedings of the comprehensive examination. The Major Advisor and the student work together to form the committee recognizing that the major advisor will have more input as she or he is likely to be more familiar with colleagues having desirable expertise. Once the members of the advisory committee have agreed to serve, the student should complete the Advisory Committee Form, including obtaining signature from each member and then submit to the TGS.

The Advisory Committee has several functions that serve the student, the major advisor, and the TGS. The student should feel comfortable approaching committee members regularly for technical or other guidance and should consider them an important resource throughout their tenure in the program. The Advisory Committee members can provide valuable feedback to both student and major advisor regarding the direction and development of the project. In addition, the SAC members are essential to administer and witness several milestones throughout the program, culminating in the thesis defense.

C2.3 Committee Meetings

It is important that the Advisory Committee be kept informed of the major findings and setbacks associated with the student's research in order to best serve as advisors. TGS mandates **at least** one committee meeting per academic year. This is important because the student must have their committee members "on board" in order to ensure that there are no "surprises" toward the end of the program regarding whether there has been sufficient accomplishment to warrant graduation.

The student is responsible for scheduling the committee meetings, usually by coordinating schedules of committee members by email in advance, and when a date and time is reached, to inform the Program Director. The committee meetings should not be viewed as intimidating or unnecessarily formal but should be anticipated in with a positive outlook and as rigorous as possible to help both the mentor and student highlight weakness that need further attention. It is recommended that committee meetings take place in the spring semester each year in accordance with required administrative milestones, including: introduction and establishing the comprehensive examination committee (year 1); finalizing the coursework proposal and presentation of the research proposal (year 2); and firming up a consensus prior to the final

defense (year 4). Prior to each meeting, the student should discuss the goals and structure of each meeting with their major advisor, who will chair each meeting. Generally, the meetings will start with a brief welcome and overview of meeting objectives by the major advisor, followed by an oral presentation of progress by the student (15-30 min). This is usually to be followed by comments and feedback from committee members, and then finalized by discussing any administrative issues (listed above) relevant to the timely progression of the student. It is recommended that the student bring any forms to be signed to each meeting (e.g. approval forms for coursework and research proposals).

Shortly following the committee meeting, the student should document the central points (e.g. members of committee present/absent, a short summary of the research presented, and specific recommendations or comments by committee members). This should be incorporated into the form Report of Research Progress and Advisory Committee Meetings. After approval by the major advisor, the form should be distributed to committee members for approval signatures, and then submitted to the TGS after approval by the PROGRAM DIRECTOR. This should all take place within two weeks of the date of the committee meeting.

Committee members are also required to submit their semi-anonymous feedback regarding specific aspects of the students' performance. This is done using a fillable committee rubric form that will be distributed to committee members as an email attachment or hard copy at the meeting. The forms are to be completed by committee members and returned to the program director either by email or hard copy. A copy of the rubric is provided in the appendix of this handbook. The Report of Research Progress and Advisory Committee Meetings form will not be turned in to TGS until all completed rubric forms are returned to the program director. The student must ensure that all committee members complete this form in order to obtain credit for the meeting. The information on the rubrics will then be compiled by the program director and forwarded to the student.

C3. Coursework:

Entry into the Physiology graduate program occurs when a student has chosen a Physiology graduate faculty member as their mentor after having completed a rotation in their laboratory. Successful completion of the core coursework in the first year in the Biomedical Sciences Program ensures a well-rounded education in the fundamentals of physiology. There is therefore less coursework in the Physiology program, and mandatory courses are designed to enhance the development of technical and presentation skills that are hallmarks of a good scientist.

C3.1 Ph.D. course requirements in the Physiology Program:

- 1st year TGS core curriculum and standard TGS requirements
- Statistics as one of the required TGS research tools
- PSIO 9010, seminar: every Fall/Spring semester enrolled (attendance and participation are required)
- PSIO 9210 (before thesis proposal approval) or PSIO 9300 (after), every semester enrolled
- Students should have a minimum 5 credit hours of advanced level courses (electives). BIOM 8130 Scientific Grant Writing is a 1 credit hour required elective that counts towards advanced course requirements. Remaining advance level courses can be any combination of the courses offered by Physiology Program or courses from the TGS catalogue if the advisor and committee

approve. Students are required to take 4 credit hours of selectives in their first year as part of the core curriculum. 6 selectives are offered by TGS (BIOM). Students can take the selectives that they did not take in their first year as advanced courses (elective) later in their training if the advisor and committee approve.

C3.2 Academic performance requirements in the Physiology Program:

The Graduate School (TGS) requires that students maintain a cumulative GPA of at least 2.8 for graduation. As an additional Physiology-specific requirement, all Physiology students must earn a minimum grade of B (3.0) or "satisfactory" for S/U courses in all courses taken after admission to the Physiology program.

The requirement for Physiology academic standards begins when a student joins the program. For first year students, this would be at the completion of the 3rd semester. For students that join the program after the 3rd semester, the Physiology academic standards will apply to all upper level courses taken to date (regardless of program).

Failure to meet these requirements will result in academic probation, and students cannot be awarded with doctoral degree while under academic probation.

Academic Probation and Dismissal

Students who fail to earn a minimum of B (3.0) or S grade in any courses while in the Physiology program will be placed on academic probation. For such students to be removed from academic probation, s/he must re-take the course and earn a minimum of B or S grade. If the course is not regularly offered, an alternate course with at least the same credit hour can be substituted with the permission of the Program Director. Students who fail to meet the Physiology grade requirement in two or more (same or different) courses shall be recommended for academic dismissal from the program.

Students who would like to appeal the dismissal should consult the Graduate Student Handbook for the procedure.

C3.3 Research progress reports (END OF EACH SEMESTER):

An essential component of the research-based courses (PSIO 9210 and PSIO 9300) is the preparation of a Research Progress Report Form at the end of each grading period. The student must complete the first part of the form "Report of Research Progress and Advisory Committee Meetings". If a committee meeting took place during that semester, then the previously submitted report can substitute. The major advisor's role is to review the report with the student and make additional comments if necessary. The student and Advisor signify approval of the report by signing the form and forwarding it to the academic administrator along with the student's grade (U or S) for the grading period. **Failure to file the report by the end of the grading period results in a grade of "incomplete" being sent to the Registrar's office.** Students are required to complete the progress report. Please see the form at the end of this handbook and submit it to The Graduate School and the Program Director.

C3.4 Physiology Course Schema

Biomedical Science PhD with a major in Physiology

	FALL (SEMESTER 1)	SPRING (SEMESTER 2)	Summer (3)
YEAR 1 **42 credit hours**	**BIOM 8011** (1): Responsible Conduct of Research **BIOM 8021** (5): Biochemistry **BIOM 8022** (5): Molecular Cell Biology **BIOM 8040** (2): Introduction to Faculty Research **BIOM 8050** (2): Introduction to Research I	**BIOM 8012** (1): Scientific Communication **BIOM 8033** (6): Integrative Systems Biology **BIOM 8060** (4): Introduction to Research II *SELECTIVE COURSES: (Choose 4 credit hours):* • **BIOM 8080** (4): Neuroscience I • **BIOM 8090** (2): Fundamentals of Genomic Medicine • **BIOM 8030** (2): Experimental Therapeutics • **BIOM 8215** (2) Fundamentals of Oncology • **BIOM 8230** (2) Biology of Proteins in Disease • **BIOM 8240** (2) Introduction to Immunology and Infectious Disease	**STAT 7070** (3): Biomedical Statistics **PSIO 9210** (9): Investigation of a Problem
	15 credit hours	15 credit hours/30	12 credit hours/42
	FALL (SEMESTER 4)	SPRING (SEMESTER 5)	SUMMER (6)
YEAR 2 **36 credit hours**	**PSIO 9210** (7-10) Investigation of a Problem **PSIO 9010** (1) Seminar in Physiology **BIOM 8130** (1) Scientific Grant Writing (Mandatory elective for Physiology) **Possible Elective(s)*:** **NURO 8082** (4) Neuroscience II **BIOM 8120** (3) Cardiovascular Physiology and Pharmacology **PSIO 8350** (1) Current Trends in Physiology **PSIO 8340** (2) Advanced Study of Physiology **PSIO 8325** (1) Current Trends in Endocrinology II **PSIO 8360** (2) Advanced Renal Physiology **PSIO 8380** (1) Medical Cardiovascular Physiology *any advanced level courses in the catalogue suitable to the program of study	**PSIO 9210** (7-11) Investigation of a Problem **PSIO 9010** (1) Seminar in Physiology **Possible Elective(s)*:** **BIOM 8030** (2) Experimental Therapeutics **BIOM 8080** (4) Neuroscience I **PSIO 8315** (2) Teaching Practicum in Physiology **PSIO 8350** (1) Current Trends in Physiology **PSIO 8340** (2) Advanced Study of Physiology **PSIO 8325** (1) Current Trends in Endocrinology II **PSIO 8360** (2) Advanced Renal Physiology **PSIO 8390** (1) Medical Renal Physiology **PSIO 8370** (1) Medical Endocrine and Reproductive Physiology *any advanced level courses suitable to the program of study	**PSIO 9210** (9-12) Investigation of a Problem **Possible Elective(s)*:** **PSIO 8350** (1) Current Trends in Physiology **PSIO 8340** (2) Advanced Study of Physiology **PSIO 8360** (2) Advanced Renal Physiology *any advanced level courses suitable to the program of study
	12 credit hours/54	12 credit hours/66	12 credit hours/78

	FALL (SEMESTER 7)	SPRING (SEMESTER 8)	SUMMER (9)
YEAR 3 **36 credit hours**	**PSIO 9210** (9-11) Investigation of a Problem (or PSIO 9300 Dissertation Research if admitted to candidacy) **PSIO 9010** (1) Seminar in Physiology **Possible Elective(s)*:** **PSIO 8350** (1) Current Trends in Physiology **PSIO 8340** (2) Advanced Study of Physiology **PSIO 8360** (2) Advanced Renal Physiology **PSIO 8380 (1)** Medical Cardiovascular Physiology *any advanced level courses in the catalogue suitable to the program of study	**PSIO 9210** (9-11) Investigation of a Problem (or PSIO 9300 Dissertation Research if admitted to candidacy) **PSIO 9010** (1) Seminar in Physiology **Possible Elective(s)*:** **BIOM 8030** (2) Experimental Therapeutics **BIOM 8080** (4) Neuroscience I **PSIO 8315** (2) Teaching Practicum in Physiology **PSIO 8350** (1) Current Trends in Physiology **PSIO 8340** (2) Advanced Study of Physiology **PSIO 8360** (2) Advanced Renal Physiology **PSIO 8390** (1) Medical Renal Physiology **PSIO 8370** (1) Medical Endocrine and Reproductive Physiology *any advanced level courses suitable to the program of study	**PSIO 9210** (12) Investigation of a Problem (or PSIO 9300 if admitted to candidacy)
	12 credit hours/90 + **PhD COMPREHENSIVE EXAM**	12 credit hours/102	12 credit hours/114 **+ PhD RESEARCH PROPOSAL**
	FALL	SPRING	SUMMER
YEAR 4-7 **36 credit hours**	**PSIO 9300** (11) Dissertation Research **PSIO 9010** (1) Seminar in Physiology	**PSIO 9300** (11) Dissertation Research **PSIO 9010** (1) Seminar in Physiology	**PSIO 9300** (12) Dissertation Research
	12 credit hours /126-4th	12 credit hours/138-4th	12 credit hours/150 4th

List of electives offered by Physiology program:

PSIO 8350 Current Trends in Physiology (1)
PSIO 8340 Advanced Study of Physiology (2)
PSIO 8325 Current Trends in Endocrinology II (1)
PSIO 8360 Advanced Renal Physiology (2)
PSIO 8380 Medical Cardiovascular Physiology (1)
PSIO 8390 Medical Renal Physiology (1)
PSIO 8370 Medical Endocrine and Reproductive Physiology (1)
PSIO 8315 Teaching Practicum in Physiology (2)

C4. Landmarks to graduation:

C4.1 Comprehensive examination

In accordance with The Graduate School (TGS) curriculum guidelines, the Department of Physiology Graduate Committee has developed the following procedure for the Comprehensive Exam for students who select the Physiology Graduate Program.

Timing: The comprehensive exam will be administered no later than the end of the 7th semester. Failure to do so indicates unsatisfactory progress toward the degree and will result in a semester grade of "U" in PSIO 9210 Investigation of a Problem course. The "U" grade will convert to an "S" if the student successfully passes both parts of the examination (written and oral) by the end of the semester following the comprehensive exam deadline AND if the only reason the "U" grade was assigned was failure to take or pass the comprehensive exam as scheduled.

An extension of one semester beyond the 7th semester may be granted by the Dean of The Graduate School, but only in rare and extenuating circumstances. All requests for such an extension must be submitted in writing to the Dean no later than the beginning of the 7th semester. Requests must provide rationale for the student's inability to take the exam in the expected timeframe. If the rationale for the delay meets the criterion for conferring an "I" grade, an extension can be granted and an "I" grade will be entered for the 7th semester PSIO 9210. The "I" grade will convert to an "S" if the student successfully passes both parts of the examination per requirements for removal of the "I" grade and by the pre-determined deadline for removal of the "I" grade. The "I" grade will convert to "U" if the examination is not passed by the pre-determined, approved deadline. Typically, the deadline will be the end of the 8th semester. If the reason the student cannot complete and pass the comprehensive exam by the deadline does not meet the stipulations for assignment of an "I" grade, the request for extension will be denied and the student will receive a grade of "U".

Goal: The goal of the comprehensive exam is to ensure that students in the Department of Physiology have a strong grounding in their given subdiscipline(s) of physiology with both a breadth and depth of knowledge to successfully complete their graduate studies. The examination should cover the scope of the student's dissertation topic, but it must not be limited to the research proposal.

Format: The discipline of physiology encompasses a wide variety of subdisciplines. Therefore, the comprehensive examination will be tailored to suit the student's area of specialization. Examination committee uses "Physiology competency" list to determine the areas of exam. However, the exam scope is not limited to this list, depending on students' research areas. The Physiology competency list can be found at the end of this handbook in the Appendix.

The exam will consist of a four-hour written exam plus a two-hour oral exam. The results of the written exam will be returned to the student within 1 week, and the oral exam will be administered no later than 4 weeks after the written exam. Student must pass the written exam to take the oral exam.

The written exam typically consists of essay questions designed to test the student's broad knowledge of his/her chosen area of study. This area will be defined by the examining committee, and should encompass a knowledge base equivalent to or exceeding specialized textbooks in the field and up to date experimental results.

The oral exam will focus in more depth on the student's chosen research area, but may include questions needed to clarify answers from the written examination.

Makeup of examination committee: The exam committee will consist of the student's Advisory Committee as described in the TGS Doctoral Guide. The Committee Chair shall be the Department Graduate Program Director, or another appointed committee member, who must be approved by the Dean of The Graduate School. The student's mentor may not serve as the chair of the examining committee. Additional experts in the chosen subdiscipline may be included for

purposes of administering the exam. The committee will collaborate to design the exam, which will require approval from the Dean of the Graduate School. PhD Comprehensive Exam Pre-Approval Form needs to be submitted at least 2 weeks prior to proposed date of exam.

Evaluation: The A – F grading scale is used for both written and oral exams (A=5 points, B=4 pts, C=3 pts, D=2 pts, and F=1 pt). For written exam, each exam committee member will grade their part of the questions in A – F scale. Grades will be converted to numerical values and averaged for final score. A 3.5 is required for passing. For the oral portion of the exam, each faculty member will provide a score of A – F based on answers to their part of the exam. Grades will be converted to numerical values and averaged for final score. An average score of 3.5 is required for passing. The student must pass both the written and oral components in order to pass the Comprehensive Examination. The exam may be retaken once in the case of a failing grade as described in TGS comprehensive exam policy. Students who fail the comprehensive exam will be given the option to switch to a Masters track (see below).

C4.2 Research proposal

The School of Graduate Studies deadline for proposal approval and admission to candidacy to be officially considered a PhD candidate is the end of 9th semester. The Department of Physiology recommends students to submit their research proposals and get the approval of their advisory committee as early as possible. The research proposal gives an opportunity to develop an overarching hypothesis and focus on specific questions from an experimental point of view. The research proposal provides a structural framework that if carried out successfully, will result in a thesis of sufficient breadth and significance to warrant successful graduation. It is recognized that this is a proposal and students will make necessary changes to the proposal depending on their results under the guidance of the advisory committee.

The proposal should follow the format of a regular grant application and have the following components:

1. **Hypothesis and Specific Aims**.
2. **Background, Significance and Innovation**.
3. **Research Strategy**.

3.1 Rationale and experimental design for each specific aim
3.2 Preliminary data for each aim (if possible)
3.3 Expected outcomes
3.4 Potential pitfall and alternative strategies
3.5 Data and statistical analysis
3.6 References
3.7 Ethical aspects: Animal or human subjects involvement

If the student had already submitted a predoctoral fellowship application, the grant application can serve as a template and preliminary data section can be expanded since there is no page limitation for the research proposal.

C4.3 Admission to candidacy for the doctor of philosophy degree

A student will be admitted to candidacy for this degree by the Dean following acceptance of the coursework proposal and research proposal, and passing of the oral and written comprehensive exams. A completed Admission to Candidacy Form must be submitted to the Dean. The Dean

notifies the student in writing of his/her admission to candidacy. Until this occurs, graduate courses taken are not credited toward the degree. A student must be eligible for candidacy for the Ph.D. degree at least two semesters before the proposed graduation date. After this step, students must register for PSIO 9300 for Dissertation Research.

C4.4 Dissertation

The dissertation is the culmination of an original investigation leading to new information that gives evidence of independent thinking, scholarly ability and critical judgment, and indicates familiarity with research methods and techniques. It can be prepared in traditional (Introduction, Aims, Methods, Results, Discussion) or manuscript style (Introduction, Manuscripts published/submitted, and Discussion). Directions for preparation of the written aspects of the dissertation are available from The Graduate School office and website.

For the traditional format, highly compact/crowded figures generally encouraged in manuscripts with limited publication space should be avoided in a dissertation, which in contrast should focus more on presenting the information in the most clear and understandable format possible. The alternative format for a dissertation that is acceptable is the compilation of papers if the thesis work has been published.

Timelines for dissertation:
A draft of the dissertation approved by the Major Advisor is distributed by the student to the Advisory Committee at least five (5) weeks before the date of the student's final oral examination. At this time, students should have at least 1 accepted/published paper directly related to their dissertation to meet the Physiology Program requirements. Students should clear manuscript requirements with their mentors early in their training as each mentor in the Physiology Program may require more than 1 paper.

At least three (3) weeks before the oral examination, the dissertation should be approved by the Advisory Committee and the Dissertation Approval Form submitted to the Dean. The signed form indicates that the members of the committee have read the draft copy of the dissertation and find it acceptable for the purpose of examining the student. The student will be responsible for making all changes recommended by the committee. At this point, students should get mailing labels from the TGS to send out dissertation defense flyer and mail by campus mail to members of TGS. A sample of the flyer is provided in the appendix.

C4.5 Dissertation defense

Satisfactory performance on the Final Oral Examination, in which the student defends his/her dissertation before the Advisory Committee, dissertation readers, faculty, students and the public, is required.

At least one reader participates in the exam and votes along with the student's Advisory Committee on the student's performance. A majority vote of the examining committee is required for satisfactory performance. It is the responsibility of the student and his/her Major Advisor to select a reader for approval by the Dean. The Graduate Studies' office must be notified when the reader agrees.

The Dean and readers must receive a corrected copy of the dissertation approved by the Advisory

Committee at least two (2) weeks before the Final Oral Examination is scheduled.

The student should contact the College of Graduate Studies office, Advisory Committee, and the reader to arrange a time that all individuals will be able to attend the oral examination. Once the time is established, notification in writing is sent to the Dean on a completed Oral Examination Faculty Agreement Form. The examination is open to the public. TGS will send out program announcement and Program Director will notify the department prior to defense.

After the Final Oral Examination, three final copies of the dissertation is submitted electronically under the guidance of TGS.

C4.6 Application for graduation

Each candidate for a graduate degree must apply for graduation. The Application for Graduation Form is available in The Graduate School office. Please read the application carefully and provide ALL requested information. This application informs The Graduate School office and the Registrar's office whether or not you will be attending graduation and/or the Graduate Studies Hooding Ceremony. It also enables the AU Bookstore to order the appropriate regalia in time for graduation. If a student believes that s/he will complete the requirements during the spring (May graduation) or fall (December graduation) semesters, the form should be completed and returned to The Graduate School office. If the form indicates that a student will graduate in time for the May or December graduation and the degree requirements are not met by that time, the student will NOT be charged for ordering regalia. However, if the requirements are completed in time and this form has not been returned, regalia may not be available for participation in hooding and graduation exercises. The Registrar also uses these forms to obtain the names for the Commencement Program for graduation and the correct names for diplomas. If an Application for Graduation has not been completed, the student will not be listed in the program.

C4.7 Fallback Masters program

For students who attempted (but not passed) or completed (passed) their comprehensive exam but not entered candidacy, there is a Fallback Masters option in place. These students are required to have generated enough data to write a Master's Research Proposal and write and defend a Master's thesis typically within one semester. If they have failed their comprehensive exam, do not have enough data and the Master's thesis proposal is not acceptable, the student will be recommended for dismissal.

Students should have (documented) support from their advisor and agreement/approval by PhD committee members, program director and TGS dean to change degree programs – and have determined if they will write a MS outline/plan or be required to submit a MS research proposal. They have to submit to TGS dean for final approval, a change of degree form (PhD →MS) with all appropriate signatures, a written plan/outline with expectations (or MS research proposal), an updated coursework proposal form and a timeline (typically one semester) for completion of the MS program. They will have one full semester to complete their Master's thesis after the final approval change to a MS degree program. Special exceptions to the one semester limit can be granted by the dean of The Graduate School. They will maintain their GRA status (stipend and insurance paid by the mentor) for at least one full semester after final approval change from PhD to a MS degree program. GRA status and funding beyond one semester is not automatic. Students may be required to pay tuition and fees after one semester in the Masters Program. They are expected to write and defend a Master's thesis (TGS standard or alternate format).

AUGUSTA UNIVERSITY
THE GRADUATE SCHOOL

Advisory Committee
Doctor of Philosophy Degree

Name of Student: _____

Graduate Program: _____

The Advisory Committee is composed of **five** individuals, one of whom is the student's Major Advisor. The Major Advisor, after consultation with the student, recommends to the Department Chair the names of four additional members of the faculty who have agreed to serve as members of the student's Advisory Committee. If a Co-Major Advisor has been appointed, s/he is one of the five committee members. At least four of the five members must hold appointments on the faculty of The Graduate School. One or two members of the committee may be from outside the student's major department or program. The advisory committee members should be selected as soon as possible after the Major Advisor is chosen. The Dean must approve the members of the Advisory Committee. The Advisory Committee's function is to assist the student in the following activities:

- Selection of courses pertinent to the objectives of the student's educational program
- Planning of the student's research/project
- Preparing and administering the Comprehensive Exam
- Critical review of the research in progress
- Defense of the dissertation

Students must hold at least one Advisory Committee meeting each year. Individual graduate programs may require more frequent meetings. All members are expected to be present at all Committee meetings. The Advisory Committee members serve as scientific resources to the student throughout his/her training, and are responsible for monitoring and evaluating the student's academic and research progress. The Advisory Committee's responsibilities include approving the student's coursework proposal, research proposal, and dissertation, administering the Final Oral Examination (dissertation defense), and determining the outcome.

If you are willing to serve on the student's committee indicated above, please sign in the space below beside your name.

Name	Signature	Date
(Committee Chair)		
Major Advisor		
Program Director		
Department Chair *(Associate Dean for Academic Affairs in Nursing or Associate Dean for Curriculum Affairs in Allied Health Sciences)*		
Mitchell A. Watsky, Ph.D. Dean, The Graduate School		

Please return to Dr.Yisang Yoon (yyoon@augusta.edu)

EVALUATION RUBRIC: **Annual Committee Meeting**

Student's Name: _____ Graduate Program: Physiology

Committee Member Name: _____ Date: _____

Evaluation/Guidance	**Poor –***provide explanation*	**Acceptable**	**Excellent**
Scientific Project			
Significance Impact on the field, medicine/compelling rationale			
Hypothesis Scope & Depth Appropriate/supported by data or papers			
Aims/Experimental Design Appropriate design/reasonable expectations/critical mass			
Progress Strong preliminary data/presentations/publications			
Student Development			
Presentation Skills Slide quality/communication skill/organization			
Knowledge Base Is the student "well read"/ understand wider implications in addition to technical details.			
Response to Questions Ability to "think on their feet"/accepting critique			

Advisory Committee comments. *Please provide suggestions to guide the student's future efforts for improvement in both categories (Scientific Project and Student Development). Results are confidential and only anonymous, summarized data will be made available to student and mentor. Continue on back if needed.*

Scientific Project:

Student Development:

AUGUSTA UNIVERSITY
THE GRADUATE SCHOOL

Report of Research Progress and Advisory Committee Meetings

NOTE: Students are required to meet with their Advisory Committees AT LEAST ONCE PER YEAR. If this report reflects the 3rd semester without a documented meeting, the student will receive a grade of UNSATISFACTORY for his/her research credit hours.

Research Progress Report
The student and Major Advisor are responsible for submitting a research progress report or an Advisory Committee meeting report at the end of each semester in which the student is enrolled for credit hours that are related to research (Investigation of a Problem or Thesis/Dissertation). This report will assist the student and his/her Advisor in focusing on the research objectives accomplished during the period and those that will be accomplished in the subsequent grading period. It is a mechanism for the student and Advisor to determine if "timely progress" is being made.

The student must complete the form and submit it to his/her Advisor for approval. The Advisor's role is to review the report with the student and make additional comments if necessary. The student and Advisor signify approval of the report by signing the form and forwarding it to the Program Director along with the student's grade (U or S) for the grading period. **Failure to file the report by the end of the grading period results in a grade of UNSATISFACTORY being sent to the Registrar's office.** Should the Advisor disagree with the student's assessment, s/he is responsible for placing in writing comments indicating the specific areas of disagreement, giving the student a copy of the comments and forwarding the form, grade and the comments to the Program's Director. Copies of the report form are forwarded to the Dean's office by the program director and placed in the student's file.

*The **Research Progress Report** should consist of two sections. Both must be completed EXCEPT for those students enrolled in the course for the first time. For them, only the second section must be completed.*

PART I. State the specific objectives achieved during this grading period in your research program. Relate the completed objectives to those you proposed to complete in your previous report and the specific aims stated in your research proposal, if appropriate. If you were unable to complete a proposed objective, state the reason(s) why and indicate what the effect may be on your progress toward completing your thesis/research project.

PART II. State the research objectives you propose to complete during your next enrollment period. These objectives should be agreed to by you and your Major Advisor.

REPORT OF ADVISORY COMMITTEE MEETING:

The student and Major Advisor are responsible for submitting an Advisory Committee meeting report at the end of each semester in which such a meeting occurred. The Advisory Committee Meeting Report serves as the student's Research Progress Report for that semester.

The Advisory Committee Meeting Report should begin with an outline or description of the materials to be presented and discussed. This should be prepared prior to the meeting, using the first page of the attached form with additional pages attached as necessary. All Advisory Committee members, the Major Advisor, and the student must sign the completed Report form, which is then submitted to the Program Director. Copies of this report form are forwarded to the Dean's office by the Program Director and placed in the student's file.

AUGUSTA UNIVERSITY
THE GRADUATE SCHOOL

Report of Research Progress and Advisory Committee Meetings Doctor of Philosophy Degree

Student Name: _____ Major Advisor: _____

Graduate Program: _____ Grading Period and Year: _____

Did you meet with your Advisory Committee this grading period? ☐ **YES** ☐ **NO**

If YES, Date of Meeting: _____

NOTE: Students are required to meet with their Advisory Committees AT LEAST ONCE PER YEAR. If this report reflects the 3rd semester without a documented meeting, you will receive a grade of UNSATISFACTORY for your research credit hours.

USE THE SPACE BELOW FOR: ***RESEARCH PROGRESS REPORT*****:** Include specific objectives achieved this grading period and research objectives for next grading period. Use additional pages as necessary.

OR FOR: ***OUTLINE FOR COMMITTEE MEETING,*** **if held:** Fill out prior to meeting. List and identify any attachments, e.g., handouts. ***Summary Report*** with Advisory Committee members' signatures also required, NEXT PAGE.

_____ _____

Student's Signature Advisor's Signature

NOTES/SUMMARY OF ADVISORY COMMITTEE MEETING (entered at meeting or completed afterwards if extensive) Approved by Student and Advisory Committee:

Date of Meeting: _____

Approved by Student and Advisory Committee:

1._____ 5._____

2._____ 6._____

3._____ 7._____

4._____ 8._____

Date: _____

Program Director: _____

AUGUSTA UNIVERSITY
THE GRADUATE SCHOOL

Coursework Proposal Form
Doctor of Philosophy Degree

Name _____ **Program** _____

Degree _____

If you approve the coursework proposed below, sign your name in the space indicated. The Major Advisor must indicate his/her approval before the student may circulate this proposal to the other members of the committee.

Authorized Signatures

Advisory Committee Member	Signature	Date
Advisory Committee Member	Signature	Date
Advisory Committee Member	Signature	Date
Advisory Committee Member	Signature	Date
Major Advisor	Signature	Date
Department Chair *(or Associate Dean for Academic Affairs in Nursing)*	Signature	Date
Program Director	Signature	Date
MD/PhD Director	Signature	Date
Dean, The Graduate School	Signature	Date

Attach JagTrax profile approved with signatures by the program director, student and mentor. ***List courses below that are not included on your JagTrax profile. Please be sure to list any electives you have taken or plan to take.***

Course No.	Title	Credit Hrs.	Course No.	Title	Credit Hrs.

REQUIRED COURSES MAY BE SUBJECT TO CHANGE

AUGUSTA UNIVERSITY
THE GRADUATE SCHOOL

Comprehensive Examination

Pre-Approval Form

Doctor of Philosophy Degree

*Please **submit completed form** to the dean for approval at least **2 weeks prior** to scheduled exam date*

The Graduate Program Director is responsible for oversight of the graduate program's Comprehensive Examinations. The Comprehensive Examination Committee or student's Advisory Committee will work with the student's Major Advisor to create the student's Comprehensive Exam. **This completed form along with the exam must be submitted through the examination committee chair and the Department Chair to TGS for approval prior to the exam.** After approval by the TGS dean or designee, the information regarding the administration and grading of the exam must be provided in writing to the student by the chair of the Comprehensive Examination Committee (Graduate Program Director - or designee approved by dean) before the examination is administered.

For more details see Ph.D. Comprehensive Exam Standard Policy

NAME of person completing /submitting this form:

DATE of form submission:

General Information

Student's Name

Student's ID #

Student's AU Matriculation Date Semester: Year: *= first semester student enrolled in PhD program*

Graduate Program

Graduate Program Director

Advisor's Name

Examination Committee Chair *= program director or dean approved designee*

Committee Members

Administration of the Examination

PART I Written Exam - 4 hours	PART II Oral Exam - 2 hours *(or biostatistics ONLY – written part 2 = 4 hours)*
Date:	**Date:**
Time of Exam: *Start* *Conclude*	**Time of Exam:** *Start* *Conclude*
Location of Exam:	**Location of Exam:**
Name of Exam Proctor:	**Name of Exam Proctor (biostats only):**

Grading Format

Grading Scale: A – F (A=5 points, B=4 points, C=3 points, D=2 points, and F=1 point)

WRITTEN EXAM: Essay Exam – No multiple choice questions. Each written exam question will be given a grade A-F. Grades will be converted to numerical value and averaged for final score. If multiple faculty members grade questions, the average score for each question will be used for the overall average score. A 3.5 is required for passing.

ORAL EXAM: Each faculty member will provide a score of A-F either based on answers to their questions or overall (programs decide – and document for standard practice). Programs can decide if there will be a discussion among faculty prior to score submission. Faculty submit scores anonymously to the Exam Committee Chair. Chair will convert scores to numerical value and average for final score. An average score of 3.5 is required for passing. No further discussion to adjust or change scores is permitted once scores have been submitted to the Chair.

Provide Additional Instructions or Information

Test Results

WRITTEN EXAM ONLY: (Biostatistics only) 0-100 scale with a minimum passing score of 75

The **written exam or Part I score** will be reported to the student and TGS no later than ***(M/D/YYYY)***

The **oral exam or Part II score** will be reported to the student and TGS no later than ***(M/D/YYYY)***

The **final score** will be reported to the student and TGS no later than***(M/D/YYYY)***

Exam Questions – NOT to be provided to the student prior to exam

Please ATTACH exam questions.

NOTE: The AU Honor Code is to be in effect for the exams

AUGUSTA UNIVERSITY
THE GRADUATE SCHOOL

Comprehensive Examination Results
Doctor of Philosophy Degree

Name of Student: _____

Graduate Program: _____ Year of Enrollment_____

Written Exam: Attempt **#1**: Score: _____ = ☐ Pass or ☐ Fail (if fail, notify TGS and provide plans for retake)

Time _____ Date _____ Place of Examination: _____

Written Exam: Attempt **#2**: Score: _____ = ☐ Pass or ☐ Fail

Time _____ Date _____ Place of Examination: _____

Oral Exam: Attempt **#1**: Score: _____ = ☐ Pass or ☐ Fail (if fail, notify TGS and provide plans for retake)

Time _____ Date _____ Place of Examination: _____

Oral Exam: Attempt **#2**: Score: _____ = ☐ Pass or ☐ Fail

Time _____ Date _____ Place of Examination: _____

Overall Results: Score: _____ Pass or Fail

Remarks (continue on back or attach separate sheet if necessary):

_____

_____

Typed Names and Signatures of Faculty Administering this Examination- Your signature below certifies the results and confirms that the exam was conducted according to the procedures approved by TGS for this program.

Name	Signature	Date
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Examination Committee Chair

_____ _____ _____

Graduate Program Director

_____ _____ _____

Department Chair (For PhD in Nursing obtain signature from CON Associate Dean for Academic Affairs)

._____ _____ _____

Dean, The Graduate School

A copy of written examination questions is filed in the office of The Graduate School. The answers are kept in the departmental files.

EVALUATION RUBRIC: **Research Proposal**

Student's Name: _____ Student's Graduate Program: _____

Name of Individual Completing this rubric: _____ Date of proposal meeting: _____

Evaluation/Guidance	**Poor** *provide explanation for each selected*	**Marginally Acceptable**	**Acceptable**	**Very Good**	**Excellent**	**Not Applicable**
1. **Problem Definition-Hypothesis:** Stated the research problem clearly, provided motivation for undertaking the research.						
2. **Specific Aims:** Provided succinct, clear, logical description of the objectives and plan of action.						
3.**Background- Literature and Previous Work:** Demonstrated sound knowledge of literature in the area, and of prior work on the specific research problem.						
4. **Significance - Impact of Proposed Research:** **(a)** Demonstrated the potential value of solution or contribution to the research problem in advancing knowledge (a) within and (b) outside the area/field of study. **(b)**						
5. **Research and Design Methods** - **Solution Approach:** Applied sound state-of-the-field research methods/tools to solve the defined problem and has described the methods/tools effectively.						
6. **Results – Preliminary Studies:** Analyzed and interpreted research results/data effectively.						
7. **Quality of Written and Oral Communication:** **(a)** Communicated research results and implications clearly and professionally in both **(a)** written and **(b)** oral form. **(b)**						
8. **Critical Thinking:** Demonstrated capability for independent research in the area of study, significant expertise in the area, and ability to make original contributions to the field.						
9. **Broader Impact:** Demonstrated awareness of broader implications of the concluded research. Broader impacts may include social, economic, technical, ethical, translational, clinical, pharmaceutical, technological or business aspects.						
10. **Publications and Presentations:** Journal or conference publications or presentations have resulted from this or related research.						
11. Optional - Program Specific Criteria (describe)						

Overall Assessment: The assessment of the overall performance of the student based on the evidence provided in items 1 – 10 (or 11) above.

CRITERIA	**PERFORMANCE RATINGS**				
	Research Proposal Unacceptable NOT approved	**Research Proposal Acceptable APPROVED**			
OVERALL- My Rating of the Research Proposal: *(select one)*	**Poor –** *provide explanation and/or suggestions*	**Marginally Acceptable**	**Acceptable**	**Very Good**	**Excellent**

Provide comments and/or suggestions:

AUGUSTA UNIVERSITY
THE GRADUATE SCHOOL

Admission to Candidacy for an Doctor of Philosophy Degree

_____, a graduate student
Name of Student

in the program of _____ has met

requirements set forth in the Graduate Student Guide for Admission to Candidacy for the

_____degree.

Authorized Signatures

Please print name and sign below.

Major Advisor_____ Date_____

Signature:_____

Program Director_____ Date _____

Signature:_____

Department Chair_____ Date_____
(or Associate Dean for Academic Affairs in Nursing)

Signature:_____

MD/PhD Director _____ Date_____
(Required for MD/PhD students)

Signature:_____

_____ Date_____
Dean, The Graduate School

AUGUSTA UNIVERSITY
THE GRADUATE SCHOOL

Dissertation Approval Form
Doctor of Philosophy Degree

TO: Members of the Advisory Committee for:

_____ _____
Name of Student Graduate Program

_____
Graduate Program Director

Your signature below indicates approval of the student's thesis/project/supervised research. Your approval at this point will not imply that there are no corrections that have to be made. Your approval will imply that there are no major alterations necessary in the investigations or in the body of the text; that the review of the literature is adequate; that the data adequately supports the conclusions; and that the quality and amount of work represented by the dissertation is, in general, consistent with the degree being sought by the student. A Final Oral Examination will not be scheduled until these criteria are met. Your approval at this point will have no bearing on the outcome of the Final Oral Examination.

_____ _____ _____
Major Advisor Signature Date

Title _____

_____

_____

Type and Sign your name in the space provided below if you feel that the dissertation is acceptable for the purpose of administering the Final Oral Examination. If you do not feel this is the case, inform the student of your criticisms so that they may be taken into account in the modifications. The student will then submit the modified manuscript to the committee.

Authorized Signatures

Names of Committee Members
(Other than Major Advisor)

_____ _____ _____
Advisory Committee Member Signature Date

_____ _____ _____
Advisory Committee Member Signature Date

_____ _____ _____
Advisory Committee Member Signature Date

_____ _____ _____
Advisory Committee Member Signature Date

Please submit completed form with signatures to the Graduate School or email to tgsenrolled@augusta.edu. The Graduate School will send a copy of the completed form to the appropriate program director.

AUGUSTA UNIVERSITY
THE GRADUATE SCHOOL

Faculty Agreement Form
Date and Time of Final Oral Examination

General Student Information

Name of Student: _____ Banner ID: _____

_____ _____
Graduate Program Degree

_____ _____ _____
Date Time Location

Authorized Signatures (Advisory Committee)

I will be in attendance for the Final Oral Examination for the student listed above on the designated day and time. I have provided a phone number to reach me on the day of the event, if needed. In addition, I have indicated below my intention to attend in-person or virtually.

Advisory Committee Member	Signature	Date	Phone Ext	☐ In Person ☐ Virtual
Advisory Committee Member	Signature	Date	Phone Ext	☐ In Person ☐ Virtual
Advisory Committee Member	Signature	Date	Phone Ext	☐ In Person ☐ Virtual
Advisory Committee Member	Signature	Date	Phone Ext	☐ In Person ☐ Virtual
Advisory Committee Member	Signature	Date	Phone Ext	☐ In Person ☐ Virtual
Advisory Committee Member	Signature	Date	Phone Ext	☐ In Person ☐ Virtual

AUGUSTA UNIVERSITY
THE GRADUATE SCHOOL

Research Proposal Form
Doctor of Philosophy Degree

General Information

Student's Name: _____ **Date:** _____

Graduate Program: _____ **Degree Sought:** _____

Proposed Title of Project: _____

Major Advisor and Committee Approval Signatures

Major Advisor Approval: The Major Advisor must indicate his/her approval before the student may circulate this proposal to the other members of the Advisory Committee.

_____ _____ _____
Major Advisor Signature Date

Advisory Committee Approval: If you approve the attached Research Proposal, type and sign your name in the space indicated below:

_____ _____ _____
Advisory Committee Member Signature Date

_____ _____ _____
Advisory Committee Member Signature Date

_____ _____ _____
Advisory Committee Member Signature Date

_____ _____ _____
Advisory Committee Member Signature Date

_____ _____ _____
Advisory Committee Member Signature Date

Additional Signatures

_____ _____ _____
Department Chair Signature Date
(or Associate Dean for Academic Affairs in Nursing)

_____ _____ _____
Program Director Signature Date

_____ _____ _____
MD/PhD Director *(for MD/PhD students)* Signature Date

_____ _____ _____
Dean, The Graduate School Signature Date

A copy of the proposal must be submitted to the Dean of The Graduate School with this form.

Student's Name:_____ **Student's Graduate Program:** _____

Rubric for Evaluating PhD Dissertation and Defense (Final Oral Exam)

Committee Members, Readers and Students are responsible for being aware of this evaluation rubric in advance of the defense.

(This page will be completed by CGS and a copy of the rubric will be distributed to the committee, readers and student just prior to the defense)

Major Advisor Name: _____ **Date of Dissertation Defense** _____

Dissertation Title _____

Advisory Committee Members
1
2
3
4
5
Dissertation Readers
1
2

At the conclusion of the defense, **each committee member and reader must complete the attached response sheets**.

For each attribute that a committee member feels is somewhat or very deficient, a short explanation should be provided. **Confidential Comment** sections at the bottom of the rubric are provided for explanations of the reasoning behind the overall evaluation of the examinee's performance if desired. Completed forms are to be treated as **confidential** and are to be **turned in to the Dean (or Dean's designee)**, not to the student.

All examination documents (rubrics and written comments) must be completed regardless of the outcome of the Dissertation Defense.

A copy of the completed forms (both rubrics and written comments) must be sent to the School of Graduate Studies Dean (or Dean's designee), within 48 h of the conclusion of the dissertation defense.

A summary of written comments and overall evaluation from the committee members **will be provided** to the student, Major Advisor, and Graduate Program Director.

Student's Name:_____ **Student's Graduate Program:** _____

Dissertation <u>DEFENSE</u> Rubric – Completed by: _____ **Date** : _____

(To be completed by each committee member & reader. Please check each evaluation criteria that you feel are appropriate within each attribute category)

Attribute	Does Not Meet Expectations *Provide a short explanation for each attribute that you select in this category.*	Meets Expectations	Exceeds Expectations
Overall quality of presentation	☐ Poorly organized ☐ Poor presentation ☐ Poor communication skills ☐ Slides and handouts difficult to read	☐ Clearly organized ☐ Clear presentation ☐ Good communication skills ☐ Slides and handouts clear	☐ Well organized ☐ Professional presentation ☐ Excellent communication skills ☐ Slides and handouts outstanding
Overall breadth of knowledge	☐ Presentation unacceptable ☐ Presentation reveals critical weaknesses in depth of knowledge in subject matter ☐ Presentation does not reflect well developed critical thinking skills ☐ Presentation is narrow in scope	☐ Presentation acceptable ☐ Presentation reveals some depth of knowledge in subject matter ☐ Presentation reveals above average critical thinking skills ☐ Presentation reveals the ability to draw from knowledge in several disciplines	☐ Presentation superior ☐ Presentation reveals exceptional depth of subject knowledge ☐ Presentation reveals well developed critical thinking skills ☐ Presentation reveals the ability to interconnect and extend knowledge from multiple disciplines
Quality of response to questions	☐ Responses are incomplete or require prompting ☐ Arguments are poorly presented ☐ Respondent exhibits lack of knowledge in subject area ☐ Responses do not meet level expected of a Ph.D. graduate	☐ Responses are complete ☐ Arguments are well organized ☐ Respondent exhibits adequate knowledge in subject area ☐ Responses meet level expected of a Ph.D. graduate	☐ Responses are eloquent ☐ Arguments are skillfully presented ☐ Respondent exhibits superior knowledge in subject area ☐ Responses exceed level expected of a Ph.D. graduate
Overall Assessment	☐ Does not meet expectations	☐ Meets Expectations	☐ Exceeds Expectations
Confidential Comments:			

Student's Name:_____ **Student's Graduate Program:** _____

DISSERTATION Rubric – Completed by: _____ **Date:** _____

(To be completed by each committee member & reader. Please check each evaluation criteria that you feel are appropriate within each attribute category)

Attribute	Does Not Meet Expectations *Provide a short explanation for each attribute that you select in this category.*	Meets Expectations	Exceeds Expectations
Overall quality of science	☐ Arguments are incorrect, incoherent, or flawed ☐ Objectives are poorly defined ☐ Demonstrates rudimentary critical thinking skills ☐ Does not reflect understanding of subject matter and associated literature ☐ Demonstrates poor understanding of theoretical concepts ☐ Demonstrates limited originality ☐ Displays limited creativity and insight	☐ Arguments are coherent and clear ☐ Objectives are clear ☐ Demonstrates average critical thinking skills ☐ Reflects understanding of subject matter and associated literature ☐ Demonstrates understanding of theoretical concepts ☐ Demonstrates originality ☐ Displays creativity and insight	☐ Arguments are superior ☐ Objectives are well defined ☐ Exhibits mature, critical thinking skills ☐ Exhibits mastery of subject matter and associated literature. ☐ Demonstrates mastery of theoretical concepts ☐ Demonstrates exceptional originality ☐ Displays exceptional creativity and insight
Contribution to discipline	☐ Limited evidence of discovery ☐ Limited expansion upon previous research ☐ Limited theoretical or applied significance ☐ Limited publication impact	☐ Some evidence of discovery ☐ Builds upon previous research ☐ Reasonable theoretical or applied significance ☐ Reasonable publication impact	☐ Exceptional evidence of discovery ☐ Greatly extends previous research ☐ Exceptional theoretical or applied significance ☐ Exceptional publication impact
Quality of writing	☐ Writing is weak ☐ Numerous grammatical and spelling errors apparent ☐ Organization is poor ☐ Documentation is poor	☐ Writing is adequate ☐ Some grammatical and spelling errors apparent ☐ Organization is logical ☐ Documentation is adequate	☐ Writing is publication quality ☐ No grammatical or spelling errors apparent ☐ Organization is excellent ☐ Documentation is excellent
Overall Assessment	☐ Does not meet expectations	☐ Meets Expectations	☐ Exceeds Expectations
Confidential Comments:			

CHECKLIST FOR DOCTOR OF PHILOSOPHY REQUIREMENTS

It is the responsibility of the student to keep this form up to date and to meet all requirements in a timely fashion. Some departments may have requirements in addition to those listed in this guide and checklist. Check your program's handbook.

DATE	PROCEDURE
_____	Program Entry Date ***(Semester/Year)***
_____	Major Advisor selected ***(Deadline: End of 2nd semester of enrollment)***
_____	Advisory Committee selected, approved by Chair and submitted to School of Graduate Studies ***(Deadline: End of 5th semester of enrollment)***
_____	Coursework Proposal approved and submitted to School of Graduate Studies
_____	Research Proposal approved and submitted to School of Graduate Studies
_____	Comprehensive Examination passed ***(Deadline for students entering Fall 2009 or later: End of 6th semester of enrollment)***
_____	Admission to Candidacy ***(At least 2 semesters, but no more than 3 years prior to Final Oral Examination)***
_____	Advisor-approved draft of dissertation submitted to members of Advisory Committee ***(5 weeks before Final Oral Examination)***
_____	Date of Final Oral Examination scheduled with School of Graduate Studies, Advisory Committee, and Readers ***(Scheduled 5 weeks in advance; examination date must be at least 3 weeks before end of graduation semester)***
_____	Faculty Agreement Form – Date and Time of Final Oral Examination Submitted to the School of Graduate Studies
_____	Application for Graduation submitted to School of Graduate Studies
_____	Corrected draft copy of Dissertation and signed Dissertation Approval Form submitted to School of Graduate Studies and Readers ***(2 weeks before Final Oral Examination)***
_____	Final Oral Examination Announcement Mailed ***(2 weeks before Final Oral Exam)***
_____	Final Oral Examination Passed
_____	Three Final Copies of Dissertation on Crane's Thesis Paper and all completed final paperwork submitted to School of Graduate Studies ***(at least 2 weeks before end of graduation semester)***

AUGUSTA UNIVERSITY
MEDICAL COLLEGE OF GEORGIA
Department of Physiology

Physiology Competency list

Cardiovascular Physiology

- ☐ Cardiac muscle
- ☐ Cardiac function
- ☐ Cardiac cycle
- ☐ Cardiac output & venous return
- ☐ Fluid dynamics
- ☐ Arterial pressure & circulation
- ☐ Vascular function
- ☐ Microcirculation
- ☐ Regulation of arterial pressure
- ☐ Local control of blood flow
- ☐ Cerebral, splanchnic and cutaneous circulation
- ☐ Exercise

Neurophysiology

- ☐ Electrophysiology
- ☐ Neurochemistry
- ☐ Cerebrospinal fluid, blood brain barrier
- ☐ Nerve conduction/EMG studies
- ☐ Autonomic nervous system
- ☐ Brainstem reflexes
- ☐ Cerebrovascular system
- ☐ Somatosensory system
- ☐ Cerebellum & basal ganglia
- ☐ Cerebral cortex
- ☐ Hypothalamus
- ☐ Limbic system
- ☐ Aging of the brain
- ☐ Memory & lateralization

Cellular & Membrane Physiology

- ☐ Biological membranes, solutes, solutions
- ☐ Excitable cells
- ☐ Regulation of cell function
- ☐ Cell motors
- ☐ Transcapillary transport
- ☐ Cell volume regulation, intracellular pH and organelles

Metabolism, Endocrinology and Reproductive Biology

- ☐ General principles
- ☐ Pituitary gland – posterior
- ☐ Pituitary gland – anterior
- ☐ Thyroid gland
- ☐ Parathyroid gland, Ca^{++} and PO_4^-
- ☐ Adrenal gland
- ☐ Pancreas
- ☐ Growth
- ☐ Endocrine integration of energy and electrolyte balance
- ☐ Reproductive physiology – male
- ☐ Reproductive system – female

Renal Physiology

- ☐ Body fluids
- ☐ Structure of the kidney and nephrons
- ☐ Renal clearance
- ☐ Glomerular filtration rate and renal hemodynamics
- ☐ Transport properties of nephron segments
- ☐ Urine concentration and dilution
- ☐ Na^+ balance and regulation of extracellular fluid volume
- ☐ K^+ balance
- ☐ Ca^{2+} and phosphate balance
- ☐ Acid-Base balance
- ☐ Integrative and pathophysiological aspects

Respiratory Physiology

- ☐ Pulmonary mechanics
- ☐ Alveolar ventilation
- ☐ Pulmonary circulation
- ☐ Pulmonary gas exchange
- ☐ Oxygen and carbon dioxide transport
- ☐ Respiratory control
- ☐ Age effects and nonrespiratory lung functions

Blood, Immune and Body Defenses

- ☐ Blood
- ☐ Hemostasis and injury, hemorrhage, shock
- ☐ Immune system (Immune cells, cytokines, innate immune response, adaptive immune response)

Comments:

Competencies expected (Adopted from the American Physiological Society)

Cellular and Membrane Physiology

Biological Membranes, Solutes and Solutions

Describe the composition of a cell membrane. Diagram its cross section, and explain how the distribution of phospholipids and proteins influences the membrane permeability of ions, hydrophilic and hydrophobic compounds.

Using a cell membrane as an example, define a reflection coefficient, and explain how the relative permeability of a cell to water and solutes will generate an osmotic pressure. Contrast the osmotic pressure generated across a cell membrane by a solution of particles that freely cross the membrane with that of a solution with the same osmolality, but particles that cannot cross the cell membrane.

Contrast the following units used to describe concentration: mM, mEq/l, mg/dl, mg%. List the typical value and normal range for plasma Na^+, K^+, H^+ (pH), HCO_3^-, Cl^-, Ca^{2+}, and glucose, and the typical intracellular pH and concentrations of Na^+, K^+, Cl^-, Ca^{2+}, and HCO_3^-.

Differentiate between the terms osmole, osmolarity, osmolality and tonicity. List the typical value and normal range for plasma osmolality.

Describe the linear relationship between forces and flows (e.g., Ohm's Law, Fick's Law of diffusion, and the law of hydrodynamic flow).

Write Fick's Law of diffusion, and explain how changes in the concentration gradient, surface area, time, and distance will influence the diffusional movement of a compound.

Based on the principle of ionic attraction, explain how a potential difference across a membrane will influence the distribution of a cation and an anion.

Define the term "steady state," and differentiate it from "equilibrium." Relate the pump-leak model of steady-state ion content to cell solute gradients and cell volume maintenance.

Define the concepts of electrochemical equilibrium and equilibrium potential, and give internal and external ion concentrations. Be able to calculate an equilibrium potential for that ion using the Nernst equation. Contrast the difference in EK (the Nernst potential for K^+) caused by a 5 mEq/l increase in extracellular K^+ with the change in ENa (the Nernst potential for Na^+) caused by a 5 mEq/l increase in extracellular Na^+.

Explain how the resting membrane potential is generated and calculate membrane potential by using either a) the Goldman-Hodgkin-Katz equation or b) the chord conductance equation. Given an increase or decrease in the permeability of K, Na, or Cl, predict how the membrane potential would change.

Differentiate the following terms based on the source of energy driving the process and the molecular pathway for: diffusion, facilitated diffusion, secondary active transport, and primary active transport.

Describe how transport rates of certain molecules and ions are accelerated by specific membrane transport proteins ("carrier" and "channel" molecules).

Describe how energy from ATP hydrolysis is used to transport ions such as Na^+, K^+, Ca^{2+}, and H^+ against their electrochemical differences (e.g., via the Na^+ pump, sarcoplasmic reticulum Ca^{2+} pump, and gastric H^+ pump).

Understand the role of ATP-binding cassette transporters in, for example, multi-drug resistance and its significance for cancer chemotherapy.

Explain how energy from the Na^+ and K^+ electrochemical gradients across the plasma membrane can be used to drive the net "uphill" (against a gradient) movement of other solutes (e.g., Na^+/glucose co-transport; Na^+/Ca^{2+} exchange or counter-transport). Apply this principle to predict possible therapies for secretory diarrhea.

Describe the role of water channels (aquaporins) in facilitating the movement of water across biological membranes.

Excitable Cells

Define the following properties of ion channels: gating, activation, and inactivation.

State the cell properties that determine the rate of electronic conduction.

Contrast the cell-to-cell spread of depolarization at a chemical synapse with that at a gap junction based on speed and fidelity (success rate). At the chemical synapse, contrast the terms temporal summation and spatial summation.

Understand the principle of the voltage clamp and how it is used to identify the ionic selectivity of channels.

Contrast the gating of ion-selective channels by extracellular ligands, intracellular ligands, stretch, and voltage.

Know the properties of voltage-gated Na^+, K^+, and Ca^{2+} channels, and understand that voltage influences their gating, activation, and inactivation.

Understand how the activity of voltage-gated Na^+, K^+, and Ca^{2+} channels generates an action potential and the roles of those channels in each phase (depolarization, overshoot, repolarization, hyperpolarization) of the action potential.

Contrast the mechanisms by which an action potential is propagated along both nonmyelinated and myelinated axons. Predict the consequence on action potential propagation in the early and late stages of demyelinating diseases, such as multiple sclerosis.

Cell Volume Regulation; Intracellular pH, and Organelles

Understand how regulation of the concentrations of K^+, Cl^-, and other Na^+ solutes influence cell volume.

Understand how various transporters (e.g. Na^+/H^+ exchange, Cl/HCO_3 exchange, $Na^{+-}HCO_3$ co-transport, etc.) contribute to the control of intracellular pH.

Describe Ca^{2+}accumulation in the sarcoplasmic and endoplasmic reticulum, mediated by Ca^{2+} ATPase.

Regulation of Cell Function

Describe how intracellular signaling pathways can influence the expression and function of proteins.

Provide examples of how phosphorylation/dephosphorylation of proteins (e.g. channels and membrane receptors) can act as negative and positive effectors of signal transduction.

Define the terms agonist and antagonist as related to membrane receptor ligands.

Diagram the intracellular signaling pathways for cholinergic nicotinic, cholinergic muscarinic, alpha-1 adrenergic, alpha-2 adrenergic, beta-1 adrenergic, beta-2 adrenergic, and beta-3 adrenergic receptors.

Contrast the receptor location and signaling pathways of peptide and steroid hormones. For peptide hormone receptors, describe the process of activation, inactivation, up-regulation, down-regulation, sensitization, and desensitization.

Cell Motors

Explain how cell molecular motors work to generate force and to transport organelles and other cargo.

Explain how the mobilization of calcium initiates contractions in smooth, striated, and cardiac muscle. Explain the sliding filament model of muscle contraction and contrast the cellular and molecular basis of muscle contraction in smooth and striated muscle.

Transcapillary Transport

Differentiate the following terms: osmotic pressure, oncotic pressure, and hydrostatic pressure, as pertains to movement across the endothelium of the capillaries.

Predict the permeability of cardiovascular capillaries to small ions/crystalloids (e.g., NaCl) and proteins (albumin) based on the capillary reflection coefficient.

Based on the Starling hypothesis, explain how permeability, hydrostatic pressure and oncotic pressure influence transcapillary exchange of fluid.

Cardiovascular Physiology

Unique Characteristics of Cardiac Muscle

Contrast the duration of the action potential and the refractory period in a cardiac muscle, a skeletal muscle, and a nerve. Sketch the temporal relationship between an action potential in a

cardiac muscle cell and the resulting contraction (twitch) of that cell. On the basis of that graph, explain why cardiac muscle cannot remain in a state of sustained (tetanic) contraction.

State the steps in excitation-contraction coupling in cardiac muscle. Outline the sequence of events that occurs between the initiation of an action potential in a cardiac muscle cell and the resulting contraction and then relaxation of that cell. Provide specific details about the special role of Ca^{2+} in the control of contraction and relaxation of cardiac muscle.

Compare cardiac and skeletal muscle with respect to: cell size, electrical connections between cells, and arrangement of myofilaments. Based on ion permeability and electrical resistance describe role of gap junctions in creating a functional syncytium.

Identify the role of extracellular calcium in cardiac muscle contraction. Identify other sources of calcium that mediate excitation-contraction coupling, and describe how intracellular calcium concentration modulates the strength of cardiac muscle contraction.

Describe the role of Starling's Law of the Heart in keeping the output of the left and right ventricles equal.

Describe the difference in the way changes in preload and changes in contractility influence ventricular force development. Compare the energetic consequences of these two separate mechanisms of force modulation.

Cardiac Function

Define preload and explain why ventricular end-diastolic pressure, atrial pressure and venous pressure all provide estimates of ventricular preload. Explain why ventricular end-diastolic pressure provides the most reliable estimate.

Define afterload and explain how arterial pressure influences afterload. Describe a condition when arterial pressure does not provide a good estimate of afterload.

Define contractility and explain why dP/dt is a useful index of contractility. Explain how the calcium transient differs between cardiac and skeletal muscle and how this influences contractility.

Define the difference between cardiac performance and cardiac contractility. Describe the impact of changes in preload, afterload, and contractility in determining cardiac performance.

Explain how changes in sympathetic activity alter ventricular work, cardiac metabolism, oxygen consumption and cardiac output.

Write the formulation of the Law of LaPlace. Describe how it applies to ventricular function in the normal and volume overloaded (failing) ventricle.

Draw a ventricular pressure volume loop and on it label the phases and events of the cardiac cycle (ECG, valve movement).

Differentiate between stroke volume and stroke work. Identify stroke volume and stroke work from a pressure-volume loop.

Define ejection fraction and be able to calculate it from end diastolic volume, end systolic volume, and/or stroke volume. Predict the change in ejection fraction that would result from a change in a) preload, b) afterload, and c) contractility.

Draw the change in pressure volume loops that would result from changes in a) afterload, b) preload, or c) contractility, for one cycle and the new steady state that is reached after 20 or more cycles.

Cardiac Cycle

Understand the basic functional anatomy of the atrioventricular and semilunar valves, and explain how they operate.

Draw, in correct temporal relationship, the pressure, volume, heart sound, and ECG changes in the cardiac cycle. Identify the intervals of isovolumic contraction, rapid ejection, reduced ejection, isovolumic relaxation, rapid ventricle filling, reduced ventricular filling and atrial contraction.

Know the various phases of ventricular systole and ventricular diastole. Contrast the relationship between pressure and flow into and out of the left and right ventricles during each phase of the cardiac cycle.

Understand how and why left sided and right sided events differ in their timing.

Cardiac Output and Venous Return

Understand the principles underlying cardiac output measurements using the Fick, dye dilution, and thermodilution methods.

Know how cardiac function (output) curves are generated and how factors which cause hypereffective or hypoeffective changes (contractility) in the heart can alter the shape of cardiac function curves.

Understand the concept of “mean systemic pressure,” its normal value, and how various factors can alter its value.

Define venous return. Understand the concept of “resistance to venous return” and know what factors determine its value theoretically, what factors are most important in practice, and how various interventions would change the resistance to venous return.

Construct a vascular function curve. Predict how changes in total peripheral resistance, blood volume, and venous compliance influence this curve.

Explain why the intersection point of the cardiac function and vascular function curves represents the steady-state cardiac output and central venous pressure under the conditions represented in the graph.

Use the intersection point of the cardiac function curve and vascular function curve to predict how interventions such as hemorrhage, heart failure, autonomic stimulation, and exercise will

affect cardiac output and right atrial pressure. Predict how physiological compensatory changes would alter acute changes.

Fluid Dynamics

Understand the relationship between pressure, flow, and resistance in the vasculature and be able to calculate for one variable if the other two are known. Apply this relationship to the arteries, arterioles, capillaries, venules, and veins. Explain how blood flow to any organ is altered by changes in resistance to that organ.

Explain how Poiseuille's Law influences resistance to flow. Use it to calculate changes in resistance in a rigid tube (blood vessel). Explain the deviations from Poiseuille's law predictions that occur in distensible blood vessels.

Explain how hemodynamics in blood vessels, especially microcirculation, deviates from theory due to anomalous viscosity, distensibility, axial streaming, and critical closing behavior.

Arterial Pressure and the Circulation

Describe the organization of the circulatory system and explain how the systemic and pulmonary circulations are linked physically and physiologically.

Describe blood pressure measurement with a catheter and transducer and explain the components of blood pressure waveform. Contrast that with the indirect estimation of blood pressure with a sphygmomanometer. Explain how each approach provides estimates of systolic and diastolic pressures. Given systolic and diastolic blood pressures, calculate the pulse pressure and the mean arterial pressure.

Describe how arterial systolic, diastolic, mean, and pulse pressure are affected by changes in a) stroke volume, b) heart rate, c) arterial compliance, and d) total peripheral resistance.

Contrast pressures and oxygen saturations in the arteries, arterioles, capillaries, venules, and veins of both the systemic and pulmonary circulations. Repeat that process for velocity of blood flow and cross-sectional area, and volume.

Identify the cell membrane receptors and second messenger systems mediating the contraction of vascular smooth muscle by norepinephrine, angiotensin II, and vasopressin.

CV 68. Identify the cell membrane receptors and second messenger systems mediating the relaxation of vascular smooth muscle by nitric oxide, bradykinin, prostaglandins, and histamine.

The Microcirculation

Explain how water and solutes traverse the capillary wall. Use Fick's equation for diffusion to identify the factors that will affect the diffusion mediated delivery of nutrients from the capillaries to the tissues. Define and give examples of diffusion-limited and flow-limited exchange.

Define the Starling equation and discuss how each component influences fluid movement across the capillary wall.

Describe the pathway for leukocyte migration across the microcirculation, including leukocyte expression of cellular adhesion molecules, and recognition sites in the vascular endothelial cells.

Starting at the post capillary venule, describe the process of angiogenesis, including the stimulus that initiates new vessel growth.

Regulation of Arterial Pressure

List the anatomical components of the baroreceptor reflex.

Explain the sequence of events in the baroreflex that occur after an acute increase or decrease in arterial blood pressure. Include receptor response, afferent nerve activity, CNS integration, efferent nerve activity to the SA node, ventricles, arterioles, venules, and hypothalamus.

Explain the sequence of events mediated by cardiopulmonary (volume) receptors that occur after an acute increase or decrease in arterial blood pressure. Include receptor response, afferent nerve activity, CNS integration, efferent nerve activity to the heart, kidney, hypothalamus, and vasculature.

Explain the sequence of events mediated by cardiopulmonary (volume) receptors that occur after an acute increase or decrease in central venous pressure. Include receptor response, afferent nerve activity, CNS integration, efferent nerve activity to the heart, kidney, hypothalamus, and vasculature.

Contrast the sympathetic and parasympathetic nervous system control of heart rate, contractility, total peripheral resistance, and venous capacitance. Predict the cardiovascular consequence of altering sympathetic nerve activity and parasympathetic nerve activity.

Contrast the relative contribution of short- and long-term mechanisms in blood pressure and blood volume regulation.

Outline the cardiovascular reflexes initiated by decreases in blood O_2 and increases in blood CO_2.

Describe the release, cardiovascular target organs, and mechanisms of cardiovascular effects for angiotensin, atrial natriuretic factor, bradykinin, and nitric oxide.

Local Control of Blood Flow

Define autoregulation of blood flow to the brain. Distinguish between short-term and long-term autoregulatory responses and the mechanisms responsible for each.

Describe how the theory of metabolic regulation of blood flow accounts for active hyperemia and reactive hyperemia.

Identify the role of PO_2 , PCO_2 , pH, adenosine, and K^+ in the metabolic control of blood flow to specific tissues.

Diagram the synthetic pathway for nitric oxide (EDRF, endothelial derived relaxing factor), including substrate and the interplay between endothelium and vascular smooth muscle.

Discuss the circumstances and the mechanisms whereby humoral substances contribute to regulation of the microcirculation.

Discuss the interaction of a) intrinsic (local), b) neural, and c) humoral control mechanisms and contrast their relative dominance in the CNS, coronary, splanchnic, renal, cutaneous, and skeletal muscle vascular beds.

Describe the role of angiogenesis in providing a long term match of tissue blood flow and metabolic need.

Cerebral, Splanchnic and Cutaneous Circulation

Contrast the local and neural control of cerebral blood flow. Discuss the relative important of O_2, CO_2, and pH in regulating cerebral blood flow.

Describe the structural components of the blood brain barrier and how this barrier impedes the movement of gases, proteins, and lipids from the blood to neurons. Identify the differences in cerebrospinal fluid and plasma relative to protein concentration, and describe the function of cerebrospinal fluid.

Contrast the mechanisms of the two major types of stroke, hemorrhagic and occlusive stroke.

Contrast the local and neural control of the splanchnic circulation. Describe the role of the hepatic portal system and the hepatic artery in providing flow and oxygen to the liver.

Describe the blood pressure in the hepatic portal vein, hepatic sinusoids, and the vena cava. Given an increase in central venous pressure, predict how hepatic microcirculatory fluid exchange will be altered, including the development of ascites.

Describe how the GI circulation is adapted for secretion and absorption. Explain the enterohepatic circulation.

Contrast local and neural control of cutaneous blood flow.

Discuss the unique characteristics of skin blood flow that are adaptive for body temperature regulation.

Exercise

Describe the cardiovascular consequences of exercise on peripheral resistance, cardiac output, A V oxygen difference, and arterial pressure.

Describe the redistribution of cardiac output during exercise to the CNS, coronary, splanchnic, cutaneous, and skeletal muscle vascular beds during sustained exercise (distance running). Explain the relative importance of neural and local control in each vascular bed.

Discuss four adaptations to physical training on the cardiovascular system. Explain the

mechanisms underlying each.

Contrast the effects of static vs. dynamic exercise on blood pressure.

Metabolism, Endocrinology and Reproductive Biology

General Principles

Explain the principle of negative feedback control of hormone secretion.

Explain the principles of positive feedback and feed forward control of hormone secretion.

Explain the bases of hormone measurements; e.g., radio-immuno assay, ELISA.

Contrast the terms endocrine, paracrine, and autocrine based on the site of hormone release and the pathway to the target tissue. Provide an example of each, and describe major differences in mechanisms of action of peptides working through membrane receptors and steroids, vitamin D, and thyroid hormones working through nuclear receptors.

Define hormone, target cell, and receptor.

Compare and contrast hormone actions that are exerted through changes in gene expression with those exerted through changes in protein phosphorylation.

Understand the effects of plasma hormone binding proteins on access of hormones to their sites of action and degradation and on the regulation of hormone secretion.

Explain the effects of secretion, excretion, degradation, and volume of distribution on the concentration of a hormone in blood plasma.

Pituitary Gland - Posterior

Contrast the anterior and posterior pituitary lobes with respect to cell types, vascular supply, development, and innervation.

List the target organs or cell types for oxytocin and describe its effects on each.

Name the stimuli for oxytocin release during parturition or lactation.

List the target cells for vasopressin and explain why vasopressin is also known as antidiuretic hormone.

Describe the stimuli and mechanisms that control vasopressin secretion

Identify disease states caused by a) over-secretion, and b) under-secretion of vasopressin and list the principle symptoms of each.

Pituitary Gland - Anterior

Describe the biosynthesis, structure, and actions of the glycoprotein hormones FSH, LH, and TSH.

Describe the biosynthesis, structure, actions, and metabolism of the GH/prolactin family.

Describe the biosynthesis, structure, and actions of the POMC family: ACTH, MSH, β-lipoprotein, β-endorphin.

Identify appropriate hypothalamic factors that control the secretion of each of the anterior pituitary hormones, and describe their route of transport from the hypothalamus to the anterior pituitary.

Diagram the short-loop and long-loop negative feedback control of anterior pituitary hormone secretion. Predict the changes in secretory rates of hypothalamic, anterior pituitary, and target gland hormones caused by over-secretion or under-secretion of any of these hormones or receptor deficit for any of these hormones.

Explain the importance of pulsatile and diurnal secretion.

Thyroid Gland

Identify the steps in the biosynthesis, storage, and secretion of tri-iodothyronine (T_3) and thyroxine (T_4) and their regulation.

Describe factors that control the synthesis, storage, and release of thyroid hormones. Explain the importance of thyroid hormone binding in blood on free and total thyroid hormone levels.

Understand the significance of the conversion of T_4 to T_3 and reverse T_3 (rT_3) in extra-thyroidal tissues.

Describe the actions of thyroid hormones on development and metabolism.

Understand the causes and consequences of a) over-secretion and b) under-secretion of thyroid hormones. Explain why either condition can cause an enlargement of the thyroid gland.

Parathyroid Gland, Ca^{++} and PO_4^-

Know the cells of origin for parathyroid hormone, its biosynthesis, and mechanism of transport within the blood (bound or free).

List the target organs and cell types for parathyroid hormone and describe its effects on each.

Identify the time course for the onset and duration for each of the biological actions of parathyroid hormone.

Describe the regulation of parathyroid hormone secretion and the role of the calcium-sensing receptor.

Understand the causes and consequences of a) over-secretion, and b) under-secretion of parathyroid hormone.

Identify the sources of vitamin D and diagram the biosynthetic pathway and the organs involved in modifying it to the biologically active $1,25(OH_2)D_3$ (1-25 dihydroxy cholecalciferol).

Identify the target organs and cellular mechanisms of action for vitamin D.

Describe the negative feedback relationship between the parathyroid hormone and the biologically active form of vitamin D [$1,25(OH_2)D_3$].

Describe the consequences of vitamin D deficiency and vitamin D excess.

Describe the actions of calcitonin and identify which (if any) are physiologically important.

Adrenal Gland

Identify the functional zones (one medullary and three cortical zones), innervation, and blood supply of the adrenal glands and the principal hormones secreted from each zone.

Describe the biosynthesis of the adrenal steroid hormones (glucocorticoids, mineralocorticoids, and androgens) and the key structural features that distinguish each class.

Understand the cellular mechanism of action of adrenal cortical hormones.

Identify the major actions of glucocorticoids on metabolism and the target organs on which they are produced.

Describe the actions of glucocorticoid hormones in injury and stress.

Describe the components of the neuroendocrine axis that control glucocorticoid secretion and describe how factors in the internal and external environment influence the neuroendocrine axis.

Identify the causes and consequences of a) over-secretion and b) under-secretion of glucocorticoids and adrenal androgens.

List the major mineralocorticoids and identify their biological actions and target organs or tissues.

Name the physiological stimuli that cause increased mineralocorticoid secretion. Relate these stimuli to regulation of sodium and potassium excretion. List the factors can modulate the secretory response and explain how they are detected.

Identify the causes and consequences of a) over-secretion and b) under-secretion of mineralocorticoids.

Diagram the negative feedback control of aldosterone secretion.

Identify the chemical nature of catecholamines, their biosynthesis, mechanism of transport within the blood, and how they are degraded and removed from the body. Identify how the structure of norepinephrine differs from epinephrine.

Describe the biological consequences of activation of the adrenal medulla and identify the target organs or tissues for catecholamines along with the receptor subtype that mediates the response. Understand the mechanism by which epinephrine and norepinephrine can produce different effects in the same tissues. Explain the change in the ratio of epinephrine to norepinephrine release from the adrenal medulla during sympathetic activation (fight and flight), or in prolonged food deprivation.

Name the key stimuli causing catecholamine secretion. List the factors that can modulate a) the secretory response and b) the responses of target tissues.

Describe the interactions of adrenal medullary and cortical hormones in response to stress.

Identify disease states caused by an over-secretion of adrenal catecholamines.

Pancreas

Identify the major hormones secreted from the endocrine pancreas, their cells of origin, and their chemical nature.

List the target organs or cell types for glucagon and describe its principal actions on each.

Identify the time course for the onset and duration of the biological actions of glucagon.

Describe the control of glucagon secretion.

List the major target organs or cell types for insulin, the major effects of insulin on each, and the consequent changes in concentration of blood constituents.

Identify the time course for the onset and duration for the biological actions of insulin.

Understand the relationship between blood glucose concentrations and insulin secretion. Describe the roles of neural input and gastrointestinal hormones on insulin secretion. List the factors that modulate the secretory response.

Identify disease states caused by: a) over-secretion, b) under-secretion of insulin, or c) decreased sensitivity to insulin, and describe the principal symptoms of each.

Growth

Describe the relationship between growth hormone and the insulin-like growth factors and their binding proteins in the regulation of growth.

Understand the regulation of growth hormone secretion. Identify the roles of hypothalamic factors and IGF-I.

Identify the target organs or cell types for insulin-like growth factors that account for longitudinal growth.

Explain how thyroid, gonadal, and adrenal hormones modulate growth.

Understand the nature and actions of local growth factors: epidermal growth factor, nerve growth factor, platelet-derived growth factor, and angiogenic and antiangiogenic factors.

Endocrine Integration of Energy and Electrolyte Balance

Identify the normal range of plasma glucose concentrations, and list the chemical forms and anatomical sites of storage pools for glucose and other metabolic substrates.

Identify the hormones that promote the influx and efflux of glucose, fat, and protein into and out of energy storage pools and their impact on the uptake of glucose by tissues. Establish specific roles for insulin, glucagon, glucocorticoids, catecholamines, growth hormone, and thyroid hormone.

Describe the changes in metabolic fuel utilization that occur in long- and short-term fasting and in acute and sustained exercise. Understand how increases or decreases in hormone secretion produce these changes.

Describe the role of appetite and metabolic rate in the maintenance of long-term energy balance and fat storage. Identify the factors that regulate appetite and fuel oxidation.

Identify the normal range of dietary sodium intake, sodium distribution in the body, and routes of sodium excretion. Explain the roles of antidiuretic hormone, aldosterone, angiotensin, and atrial natriuretic hormone in the regulation of sodium balance.

Identify the normal range of dietary potassium intake, potassium distribution in the body, and routes of potassium excretion. Explain how acute changes in aldosterone, insulin, and acid/base concentrations affect the plasma potassium concentration and the movement of potassium into and out of the intracellular compartment. Explain the chronic regulation of body potassium balance and plasma potassium levels by aldosterone through its actions on renal excretion, intestinal excretion, and dietary appetite/absorption.

Identify the normal range of dietary calcium intake, calcium distribution in the body, and routes of calcium excretion. Explain the regulation of the plasma calcium concentration by parathyroid hormone, vitamin D, and calcitonin based on exchange with bone, renal excretion, and intestinal excretion and/or absorption.

Identify the normal range of dietary phosphate intake, phosphate distribution in the body, and routes of phosphate excretion. Explain the regulation of the plasma phosphate concentration by parathyroid hormone, vitamin D, and calcitonin based on exchange with bone, renal excretion, intestinal excretion and/or absorption.

Reproductive Physiology - Male

Describe the physiological functions of the major components of the male reproductive tract.

Describe spermatogenesis and the role of different cell types in this process.

Describe the endocrine regulation of testicular function: the role of the GnRH pulse generator, FSH, LH, testosterone, and inhibin.

Identify the cell of origin for testosterone, its biosynthesis, mechanism of transport within the blood, how it is metabolized and how it is eliminated. List other physiologically produced androgens.

List the target organs or cell types for testosterone and describe its effects on each.

Describe the cellular mechanisms of action for testosterone.

List the neural, vascular, and endocrine components of the erection and ejaculation response.

Identify the causes and consequences of over-secretion and under-secretion of testosterone for a) prepubertal and b) postpubescent males.

Compare and contrast the actions of testosterone, dihydrotestosterone, estradiol, and Müllerian inhibitory factor in the development of the male and female reproductive tracts.

Reproductive System - Female

Describe oogenesis and its relationship to changes in the ovarian follicle. Explain the roles of FSH, LH, estradiol, inhibin, and paracrine agents in oogenesis and follicular maturation.

Describe ovulation and the formation and decline of the corpus luteum and the roles of pituitary hormones in each of these processes.

Describe the hormonal regulation of estrogen and progesterone biosynthesis and secretion by the ovary. Identify the cells responsible for their biosynthesis, the mechanism of their transport in the blood, and how they are degraded and removed from the body.

List the target organs or cell types for estrogen action and describe its effects on each.

Describe the cellular mechanisms of action for estrogen.

List the principal physiological actions of progesterone, its target organs or cell types, and describe its effects on each and the importance of “estrogen priming.”

Describe the cellular mechanisms of action for progesterone.

With time on the x-axis, diagram the changes in the endometrium and the ovary seen during the menstrual cycle and correlate these changes with changes in blood levels of FSH, LH, estradiol, progesterone, and inhibin. Describe how the changes in ovarian steroids produce the proliferative and secretory phases of the uterine endometrium and menstruation and the changes in basal body temperature during the menstrual cycle.

List the protein hormones secreted by the placenta and describe the role of human chorionic gonadotropin (hCG) in the rescue of the corpus luteum in maintaining pregnancy early post-implantation.

Describe the interactions between the placenta and the fetal adrenal cortex in the production of estrogens during pregnancy.

Discuss the roles of oxytocin, relaxin, and prostaglandins in the initiation and maintenance of parturition.

Explain the role of estrogens, progesterone, placental lactogen, prolactin, and oxytocin in mammary gland development during puberty, pregnancy, and lactation.

Explain the basis for the inhibition of milk secretion during pregnancy and the initiation of lactation after parturition.

Differentiate between milk secretion and milk ejection, and describe the hormonal regulation of both during lactation, including the role of suckling.

Explain the physiological bases for the antifertility actions of contraceptive steroid hormones.

Describe the age-related changes in the male and female reproductive systems, including the mechanisms responsible for these changes, at the following times:

a. In utero development
b. Puberty
c. Senescence

Neurophysiology

Electrophysiology

Define, and identify on a diagram of a neuron, the following regions: dendrites, axon, axon hillock, soma, and synaptic cleft.

Write the Nernst equation, and explain the effects of altering either the intracellular or extracellular Na^+, K^+, Cl^-, or Ca^{2+} concentration on the equilibrium potential for that ion.

Describe the normal distribution of Na^+, K^+, Ca^{2+}, and Cl^- across the cell membrane, and using the chord conductance equation, explain how the relative permeabilities to these ions create a resting membrane potential.

Describe ionic basis of an action potential.

Contrast the generation and conduction of graded potentials with that of action potentials, identifying on the neuron the area in which each occurs.

Describe the basis for the calculation of the space constant and time constant of neuron process.

Define membrane capacitance and identify how membrane capacitance affects the spread of current in myelinated and demyelinated neurons.

Compare conduction velocities in a compound nerve, identifying how the diameter and myelination lead to differences in conduction velocity, and the use of these differences to classify neurons as group Ia, Ib, II, III, IV fibers or as A_{alpha}, A_{beta}, A_{delta}, b, and c fibers.

Describe the ionic basis for inhibitory and excitatory post-synaptic potentials and how these changes can alter synaptic transmission.

Distinguish the effects of hyperkalemia, hypercalcemia, and hypoxia on the resting membrane and action potential.

Describe the effects of demyelination on action potential propagation and nerve conduction.

Neurochemistry

Compare electrical and chemical synapses transmission based on velocity of conduction, fidelity, and the possibility for neuromodulation (facilitation or inhibition).

Describe chemical neurotransmission, listing in correct temporal sequence events beginning with the arrival of a wave of depolarization at the pre-synaptic membrane and ending with a graded potential generated at the post-synaptic membrane.

Define the characteristics of a neurotransmitter.

Learn the synthetic pathways, inactivation mechanisms and neurochemical anatomy and mechanisms of receptor transduction for the following neurotransmitters:

1. Catecholamines (DA, NE, E)
2. Acetylcholine (ACh)
3. Serotonin (5-hydroxytryptamine; 5-HT)
4. Histamine
5. GABA (gamma-aminobutyric acid)
6. Glutamate
7. Endorphins
8. Enkephalins
9. Dynorphins
10. Substance P

Learn the major receptor classifications and representative receptor agonists and antagonists for the above transmitters.

Describe the relationships between neurotransmitter dysfunction and neuropathology.

Cerebrospinal Fluid, Blood Brain Barriers

Diagram the adult ventricular system

Identify on a diagram the meninges and subarachnoid spaces.

Describe formation and reabsorption of cerebral spinal fluid, including the anatomy and function of the choroid plexi.

Describe the normal pressure, volume, and composition of the CSF.

Describe how CSF can vary in certain pathological conditions.

Describe the endothelial basis of the blood-brain barrier, and predict the consequence of this barrier for the central nervous system distribution of intravenously administered hydrophilic and hydrophobic drugs

Nerve Conduction/EMG Studies

Describe the procedure used for measuring nerve conduction velocity.

Describe the repetitive nerve stimulation procedure for assessing the integrity of the neuromuscular junction.

Describe the physiological deficit and the consequence for patients with myasthenia gravis.

Autonomic Nervous System

Contrast the sympathetic and parasympathetic branches of the autonomic nervous system based on: spinal cord division of origin, length of preganglionic and postganglionic neurons, neurotransmitters and receptors at the ganglionic and target organ synapse.

List the sensory input of the ANS.

List the major central nervous system control centers of the ANS.

Describe the functional effects of normal and abnormal ANS activity or lack of activity.

Brainstem Reflexes

Describe the function of the following brain stem reflexes: cardiovascular baroreceptor, respiratory stretch receptor.

For each brain stem reflex, list the stimulus and its receptor, the afferent pathway, the brain stem nuclei involved, the efferent pathway and the resulting effect.

Cerebrovascular System

Describe the local factors affecting brain blood flow, and contrast their effectiveness with that of autonomic regulation of cerebral blood flow.

Describe cerebrovascular disorders (stroke, aneurysm, migraine headache) as to primary cause and effect, including how excitotoxic mechanisms can lead to neuronal death following stroke or injury.

Somatosensory System. Define and contrast point localization and two-point discrimination in psychophysical and neurophysiological terms. Explain why the threshold for two-point discrimination changes in different areas of the body surface, e.g., lips, fingertips and back.

Contrast the proprioceptive pathways to the cerebellum with that to the cerebral cortex.

Differentiate the submodalities of nondiscriminative touch, temperature and nociception based on receptor transduction mechanism, localization within the spinal gray matter, and central termination of the pathways.

Describe the control of pain perception, including central processing and the role of endorphins.

Describe gating mechanism theory for control of pain transmission, and relate it to the use of TENS (transcutaneous electrical nerve stimulation) and spinal cord stimulation.

Cerebellum and Basal Ganglia

Describe the roles of the cerebellum in the regulation of skilled movement.

List three functional divisions of the cerebellum, detailing the input and output connections of each. Be able to differentiate the functions of each and their integration with lateral and medial motor systems.

Draw and label the circuitry of the cerebellar cortex, assign the functional role of each neuron type and give its synaptic action (excitatory/inhibitory). Be able to describe how this circuit functions as a timing mechanism and how it produces synergy in opposing muscle groups.

On the basis of input-output organization, somatotopic organization, and overall function, predict the neurological disturbances that can result from disease or damage in different regions of the cerebellum.

Contrast the spinal proprioceptive pathways to the cerebellum with those to the cortex.

List and describe the major interconnections between components of the basal ganglia and the motor cortex. Identify the neurotransmitters determining the flow of information in the system.

Describe the overall function of the basal ganglia in movement control and initiation in association with medial and lateral motor systems.

List the appropriate signs of rigidity, dyskinesias, akinesia, and tremor for Parkinsonism, chorea, hemiballism, and athetosis. Assign a likely lesion site or chemical system defect for each clinical syndrome.

Describe the rationale for treatment of Parkinsonism with anticholinergic drugs, L-DOPA, or transplantation of catecholamine-producing cells.

Cerebral Cortex

Describe the medial to lateral, rostral to caudal, and surface to white matter organizations of the primary motor cortex and the premotor cortex. Draw those regions on a sketch of the brain and also locate the supplementary motor cortex.

Compare the effects of electrical stimulation of motor cortex and premotor cortex, relating the expected results to the control of voluntary movement.

Describe the origin, course, and termination of the pyramidal tract.

Compare the consequences of upper motor neuron loss to lower motor neuron loss. Describe the consequences of pyramidal tract transection.

Draw a “flow diagram” for the brain regions involved in planning, initiating, and properly executing a skilled voluntary movement.

Identify Brodmann areas for visual, auditory, somatic sensory, motor, and speech areas.

Identify the cortical areas that receive projections from the following thalamic nuclei: ventral lateral, dorsomedial, pulvinar, medial geniculate, lateral geniculate, ventral posterolateral, and posteromedial.

Describe the cortical areas important for language.

Describe the cortical area important for spatial relations.

Hypothalamus

Describe the structure of the hypothalamus, including the major hypothalamic nuclei and areas.

Describe the major functions of the hypothalamus and its nuclei/areas.

Describe the role and mechanisms of the hypothalamus as it relates to thirst, hunger, temperature regulation, and the defense mechanism.

Limbic System

Describe the major components and functions of the limbic system.

Describe the major afferent and efferent connections and functions of the amygdala.

Describe the functions of the hippocampus.

Describe the functions of the amygdala.

Describe the role of dopamine in the limbic system in disorders of thought and disorders of mood.

Aging of the Brain

Describe the gross, histological and biochemical changes that occur in the brain through aging.

Describe dementia.

Describe the characteristics of Alzheimer’s disease.

Memory and Lateralization

List the parts of the brain that appear to be involved in memory in mammals, and summarize the proposed role of each in memory processing and storage.

Explain the mechanisms proposed for short term and long-term memory storage.

List the major differences in hemispheric function in humans.

Renal Physiology

Body Fluids

Given the body weight and percent body fat, estimate the a) total body water, b) lean body mass, c) extracellular fluid volume, d) intracellular fluid volume, e) blood volume, and f) plasma volume. Identify normal extracellular fluid (plasma) osmolarity and concentrations of Na^+, K^+, Cl^-, HCO_3^-, proteins, creatinine, and urea, and contrast these values with those for intracellular fluids.

Given the composition and osmolality of a fluid, identify it as hypertonic, isotonic, or hypotonic. Predict the change in transcellular fluid exchange that would be caused by placing a red blood cell in solutions with varying tonicities.

Identify major routes and normal ranges for water intake and loss, and predict how changes in intake and loss affect the distribution of total body water.

Demonstrate the ability to use the indicator dilution principle to measure plasma volume, blood volume, extracellular fluid volume, and total body water, and identify compounds used to measure each volume.

Identify the site of erythropoietin production, the adequate stimulus for erythropoietin release, and the target tissue for erythropoietin action.

Structure of the Kidney and Nephrons

Given a cross section of a kidney, identify the renal cortex, renal medulla, renal calycies, medullary pyramids, renal pelvic space, renal artery, renal vein, and ureter.

Describe in sequence the tubular segments through which ultrafiltrate flows after it is formed at Bowman's capsule to when it enters the renal pelvis. Identify each structure as being located in the renal cortex or renal medulla. Based on the glomerulus location and the length of the loop of Henle, distinguish between cortical and juxtamedullary nephrons.

Describe in sequence the blood vessels through which blood flows when passing from the renal artery to the renal vein, including the glomerular blood vessels, peritubular capillaries, and the vasa recta.

On an electron micrograph and a line drawing, identify the following structures of the glomerular tuft: the afferent and efferent arterioles, glomerular capillary network, mesangium, Bowman's capsule, and the juxtaglomerular apparatus (including the specialized juxtaglomerular arteriole cells and the macula densa). Describe the three layers comprising the glomerular filtration barrier, and identify podocytes, foot processes, slits, and the basement membrane.

Renal Clearance

Explain the clearance principle. Use the clearance equation and an appropriate compound to estimate the glomerular filtration rate, renal plasma flow, and renal blood flow.

Distinguish between the use of inulin and creatinine clearances as measures of the glomerular filtration rate.

Given the plasma and urine concentrations and the urine flow rate, calculate the filtered load, tubular transport, excretion rate, and clearance of inulin, creatinine, para-amino hippuric acid (PAH), glucose, and penicillin. Predict how changes in filtration, reabsorption, and secretion will affect renal excretion of each compound.

Glomerular Filtration Rate and Renal Hemodynamics

Identify the filtration barriers, if any, which impede the filtration of H_2O, Na^+, inulin, albumin, and red blood cells.

Define renal blood flow, renal plasma flow, glomerular filtration rate, and filtration fraction and list typical values.

Define the filtration coefficient at the glomerular capillary, describe the membrane properties that contribute to it, and explain its role in determining GFR.

Given the capillary and Bowman's capsule hydrostatic and oncotic pressures, calculate the net filtration force at the glomerular capillaries. Predict the changes in glomerular filtration caused by increases or decreases in any of those pressures.

Describe the relative resistances of the afferent and efferent arterioles and the effects on renal blood flow and GFR of selective changes in each.

Describe the myogenic and tubuloglomerular feedback mechanisms that mediate the autoregulation of renal plasma flow and glomerular filtration rate.

Predict the change in renal blood flow and glomerular filtration rate caused by an increase in renal sympathetic nerve activity.

Predict the change in renal blood flow and glomerular filtration caused by: a) increased synthesis of angiotensin II, b) increased release of atrial natriuretic peptide, c) increased prostaglandin formation, and d) increased nitric oxide formation.

Identify which components of the filtration barrier whose damage would result in hematuria and proteinuria.

Compare blood flow to, and oxygen consumption by, the kidneys with that of skeletal muscle and cardiac muscle.

Describe the effects of changes in peritubular capillary hydrostatic and colloid osmotic pressures on net proximal tubular fluid reabsorption.

Transport Properties of Nephron Segments

Using glucose, para-amino hippuric acid (PAH), water, and Cl^-, contrast the transcellular and paracellular pathways for movement across proximal tubular epithelia.

Distinguish between active (primary and secondary) transport, facilitated diffusion, and passive diffusion based on energy source and carrier protein involvement.

Describe the contribution of the major nephron segments to the reabsorption of the filtered load of solute and water.

Describe the cellular mechanisms for the transport of Na^+, Cl^-, K^+, HCO_3^-, Ca^{2+}, phosphate, organic solutes (e.g., glucose, amino acids, and urea), and water by the major tubular segments.

Describe the function of the following renal transporters and their predominant localization along the tubules with regard to nephron segment and apical versus basolateral membranes

a. Transport ATPases (Na^+/K^+-ATPase, H^+/K^+-ATPase, H^+-ATPase, and Ca^{2+}-ATPase)

b. Ion and water channels (K^+, ENaC, Cl^-, Ca^{2+}, aquaporins)

c. Coupled transporters (Na^+-glucose, Na^+/H^+-antiporter, Na^+-K^+-$2Cl^-$-symporter,

Na^+-phosphate symporter, Na^+-Cl^--symporter, Na^+-HCO_3^--symporter, Cl^-/HCO_3^--antiporter)

Describe the nephron sites and molecular mechanisms of action of the following classes of diuretics (osmotic, carbonic anhydrase inhibitors, loop, thiazide, K^+-sparing).

Describe clinical syndromes related to defects in specific renal transporters (e.g., Bartter's, Gittelman's, Liddle's, etc.).

Describe the effects of reductions in GFR on plasma creatinine concentrations and plot the relationship

Urine Concentration and Dilution

Identify the two most powerful stimuli that cause ADH release, and describe the negative feedback control mechanisms for each.

Describe the role of the ascending limb of the loop of Henle in producing a high renal interstitial fluid osmolality. Beginning with the loop of Henle, contrast the tubular fluid and interstitial fluid osmolality changes that allow either a dilute or a concentrated urine to be produced and excreted.

Predict the consequence on urine concentrating ability if the medullary osmotic gradient is disrupted. Following disruption, describe how the osmotic gradient would be re-established.

Identify the tubular section and cellular mechanism by which ADH increases permeability to water and urea. Describe the role of these changes on the ability of the kidney to produce either a dilute or a concentrated urine.

Distinguish between central and nephrogenic diabetes insipidus based on plasma ADH levels and the response to an injection of ADH.

Na^+ Balance and Regulation of Extracellular Fluid Volume

Identify the normal range of dietary Na^+ intake and major routes of Na^+ loss from the body. Define the role of Na in maintaining extracellular fluid volume.

Calculate the normal filtered load of Na^+. Identify the tubular sites of Na reabsorption, and the alterations in Na^+ reabsorption in conditions of euvolemia, volume depletion, and volume expansion.

Describe the receptors involved in the monitoring of ECF volume (e.g., high-pressure baroreceptors and low-pressure cardiopulmonary stretch receptors), and diagram the neural reflex regulation of renal Na^+ and water excretion.

Diagram the formation and generation of angiotensin II, beginning with renin. Identify four factors that can promote renin release.

Describe the regulation of Na^+ reabsorption along the nephron, including the effects of sympathetic nerves, angiotensin II, aldosterone, and atrial natriuretic peptide

Explain the contribution of the kidneys to progression of and/or the compensation for the altered fluid volume regulation characteristic of congestive heart failure and hepatic cirrhosis.

Describe the regulation of proximal tubule reabsorption that underlies the phenomenon of glomerulotubular balance.

Describe the role of the renin-angiotensin-aldosterone system in the regulation of systemic arterial blood pressure in volume-replete and volume-depleted states and in secondary forms of hypertension.

K^+ Balance

Describe K^+ distribution within the body, extrarenal K^+ homeostasis, and the role insulin, epinephrine, and aldosterone play in the movement of K^+ between intracellular and extracellular pools. Describe the K^+ shift caused by acidosis

Describe the factors that regulate K^+ secretion in the collecting duct (i.e., aldosterone, plasma K^+) and distinguish these from factors that alter K^+ secretion at this site (i.e., luminal fluid flow rate, acid-base disturbances, anion delivery).

Contrast the tubular sites of action of K^+ wasting and K^+ sparing diuretics.

Ca^{2+} and Phosphate Balance

Identify the normal range of dietary Ca^{2+} and phosphate intake, major storage pools of Ca and phosphate, and major routes of Ca^{2+} and phosphate loss from the body. Describe the regulation of plasma Ca^{2+} by calcitonin and phosphate by parathyroid hormone.

Describe the renal regulation of Ca^{2+} and phosphate transport by PTH, calcitonin, and 1,25-dihydroxy vitamin D (calcitriol), and distinguish from other factors that alter their transport (ECF volume, acid-base disorders).

R 64. Describe the role of the kidney in the production of 1,25-dihydroxy vitamin D (calcitriol).

Describe the effects of diuretics on Ca^{2+} and phosphate excretion, especially noting the effect of thiazides to decrease Ca^{2+} excretion and loop diuretics to increase Ca^{2+} excretion.

Acid-Base Balance

Identify the normal range of pH values, and the upper and lower limits compatible with life. Describe the role of buffers in maintaining pH, including the roles of the lungs and kidneys.

Describe the respiratory and renal regulation of the CO_2/HCO_3^- buffer system, which allows a buffer with a pK_a of 6.1 to be physiologically important in the maintenance of the normal plasma pH of 7.4.

Distinguish between CO_2-derived (volatile acid) and nonvolatile acid, the relative amounts produced each day through dietary intake and cellular metabolism, and the normal routes of loss from the body.

Describe the adjustments in filtered load and HCO_3^- reabsorption (H^+ secretion) by alterations in systemic acid-base balance and distinguish from factors that alter this process (i.e., ECF volume, aldosterone, and angiotensin II).

Describe net acid excretion by the kidneys, titratable acid, the importance of urinary buffers, and the production and excretion of ammonium. Distinguish between the reclamation of filtered bicarbonate and the formation of new bicarbonate.

Describe processes that lead to acid-base disturbances and list common causes

Integrative and Pathophysiological Aspects

Describe the relationships between sodium balance and plasma volume as they contribute to cardiovascular hemodynamics and arterial pressure.

Describe pressure natriuresis and the mechanisms mediating and modulating this process.

Describe how impairments in renal function and pressure natriuresis contribute to the long-term regulation of arterial pressure and the development and maintenance of hypertension.

Respiratory Physiology

Pulmonary Mechanics

Diagram how pleural pressure, alveolar pressure, airflow, and lung volume change during a normal quiet breathing cycle. Identify on the figure the onset of inspiration, cessation of inspiration, and cessation of expiration. Describe how differences in pressure between the atmosphere and alveoli cause air to move in and out of the lungs.

Draw a normal pulmonary pressure-volume (compliance) curve (starting from residual volume to total lung capacity and back to residual volume), labeling the inflation and deflation limbs. Explain the cause and significance of the hysteresis in the curves.

Define compliance and identify two common clinical conditions in which lung compliance is higher or lower than normal.

Identify the forces that generate the negative intrapleural pressure when the lung is at functional residual capacity, and predict the direction that the lung and chest wall will move if air is introduced into the pleural cavity (pneumothorax).

Define the factors that determine total lung capacity, functional residual capacity, and residual volume. Describe the mechanisms responsible for the changes in those volumes that occur in patients with emphysema and pulmonary fibrosis.

Describe the principal components of pulmonary surfactant and explain the roles of each.

Describe the effects of airway diameter and turbulent flow on airway resistance.

Describe how airway resistance alters dynamic lung compliance.

Differentiate between the two broad categories of restrictive and obstructive lung disease, including the spirometric abnormalities associated with each category.

Describe the regional differences in alveolar ventilation in healthy and diseased lungs and explain the basis for these differences.

Alveolar ventilation

Define partial pressure and fractional concentration as they apply to gases in air. List the normal fractional concentrations and sea level partial pressures for O_2, CO_2, and N_2.

Define and contrast the following terms: anatomic dead space, physiologic dead space, wasted (dead space) ventilation, total minute ventilation and alveolar minute ventilation.

Define and contrast the relationships between alveolar ventilation and the arterial PCO_2 and PO_2.

Describe in quantitative terms the effect of ventilation on PCO_2 according to the alveolar ventilation equation.

Be able to estimate the alveolar oxygen partial pressure (PAO_2) using the simplified form of the alveolar gas equation. Be able to use the equation to calculate the amount of supplemental O_2 required to overcome a reduction in PAO_2 caused by hypoventilation or high altitude.

Define the following terms: hypoventilation, hyperventilation, hypercapnea, eupnea, hypopnea, and hyperpnea.

Pulmonary Circulation

Contrast the systemic and pulmonary circulations with respect to pressures, resistance to blood flow, and response to hypoxia.

Describe how pulmonary vascular resistance changes with alterations in cardiac output or pulmonary arterial pressure. Explain in terms of distention and recruitment of pulmonary vessels. Identify the zones in which these two mechanisms apply.

Describe how pulmonary vascular resistance changes with lung volume. Explain in terms of alterations in alveolar and extra-alveolar blood vessels.

Describe the consequence of hypoxic pulmonary vasoconstriction on the distribution of pulmonary blood flow.

Describe the effects of inspired nitric oxide on pulmonary vascular resistance and hypoxic vasoconstriction.

Explain the development of pulmonary edema by a) increased hydrostatic pressure, b) increased permeability, c) impaired lymphatic outflow or increased central venous pressure, and d) hemodilution (e.g., with saline volume resuscitation).

Describe the major functions of the bronchial circulation.

Pulmonary Gas Exchange

Name the factors that affect diffusive transport of a gas between alveolar gas and pulmonary capillary blood.

Describe the kinetics of oxygen transfer from alveolus to capillary and the concept of capillary reserve time (i.e., the portion of the erythrocyte transit time in which no further diffusion of oxygen occurs).

Define oxygen diffusing capacity, and describe the rationale and technique for the use of carbon monoxide to determine diffusing capacity.

Describe the normal relative differences from the apex to the base of the lung in alveolar and arterial PO_2, PCO_2, pH, and oxygen and carbon dioxide exchange.

Predict how the presence of abnormally low and high V/Q ratios in a person's lungs will affect arterial PO_2 and PCO_2.

Describe the airway and vascular control mechanisms that help maintain a normal

ventilation/perfusion ratio. Name two compensatory reflexes for V/Q inequality.

Oxygen and Carbon Dioxide Transport

Define oxygen partial pressure (tension), oxygen content, and percent hemoglobin saturation as they pertain to blood.

Draw an oxyhemoglobin dissociation curve (hemoglobin oxygen equilibrium curve) showing the relationships between oxygen partial pressure, hemoglobin saturation, and blood oxygen content. On the same axes, draw the relationship between PO_2 and dissolved plasma O_2 content (Henry's Law). Compare the relative amounts of O_2 carried bound to hemoglobin with that carried in the dissolved form.

Describe how the shape of the oxyhemoglobin dissociation curve influences the uptake and delivery of oxygen.

Show how the oxyhemoglobin dissociation curve is affected by changes in blood temperature, pH, PCO_2, and 2,3-DPG, and describe a situation where such changes have important physiological consequences.

Describe how anemia and carbon monoxide poisoning affect the shape of the oxyhemoglobin dissociation curve, PaO_2, and SaO_2.

List the forms in which carbon dioxide is carried in the blood. Identify the percentage of total CO_2 transported as each form.

Identify the enzyme that is essential to normal carbon dioxide transport by the blood and its location.

Draw the carbon dioxide dissociation curves for oxy- and deoxyhemoglobin. Describe the interplay between CO_2 and O_2 binding on hemoglobin that causes the Haldane effect.

Define respiratory acidosis and alkalosis and give clinical examples of each.

Describe the mechanism and function of respiratory acid base compensations.

Respiratory Control

Identify the regions in the central nervous system that play important roles in the generation and control of cyclic breathing.

Give three examples of reflexes involving pulmonary receptors that influence breathing frequency and tidal volume. Describe the receptors and neural pathways involved.

. Describe the respiratory drive in a COPD patient, and predict the change in respiratory drive when oxygen is given to a COPD patient.

Describe the mechanisms for the shift in alveolar ventilation that occur immediately upon ascent to high altitude, after remaining at altitude for two weeks, and immediately upon return

to sea level.

Describe the physiological basis of shallow water blackout during a breath-hold dive.

Describe the significance of the feedforward control of ventilation (central command) during exercise, and the effects of exercise on arterial and mixed venous PCO_2, PO_2, and pH.

Age Effects and Nonrespiratory Lung Functions

Describe the effect of aging on lung volumes, lung and chest wall compliance, blood gases, and respiratory control.

Identify the mechanism by which particles are cleared from the airways.
Describe mechanisms for clearance of vasoactive substances from the blood during passage through the lung. Identify a substance that is almost completely cleared and one that is not cleared to any significant extent.

Blood, Immune, Body Defenses

Blood

Describe the components of blood (cells, ions, proteins, platelets) giving their normal values. Relate the three red blood cell concentration estimates, red blood cell count, hematocrit, and hemoglobin concentration.

Identify the source, stimulus for formation, and function of the hormone erythropoietin. Relate the rate of red blood cell synthesis to the normal red blood cell life span and the percentage of immature reticulocytes in the blood.

Describe the functional consequence of the lack of a nucleus, ribosomes, and mitochondria for a) protein synthesis and b) energy production within the red blood cell.

Discuss the normal balance of red blood cell synthesis and destruction, including how imbalances in each lead to anemia or polycythemia.

Explain how red blood cell surface antigens account for typing of blood by the A B O system and rhesus factor. Based on these antigens, identify blood type of a “universal donor” and a “universal recipient.”

Hemostasis and Injury, Hemorrhage, Shock

Diagram the enzymes and substrates involved in the formation of fibrin polymers, beginning at prothrombin. Contrast the initiation of thrombin formation by intrinsic and extrinsic pathways.

Contrast the mechanisms of anticoagulation of a) heparin, b) EGTA, and c) coumadin. Identify clinical uses for each agent.

Describe the mechanisms of fibrinolysis by TPA, tissue plasminogen activator and urokinase.

Explain the role of the platelet release reaction on clot formation. Distinguish between a thrombus and an embolus.