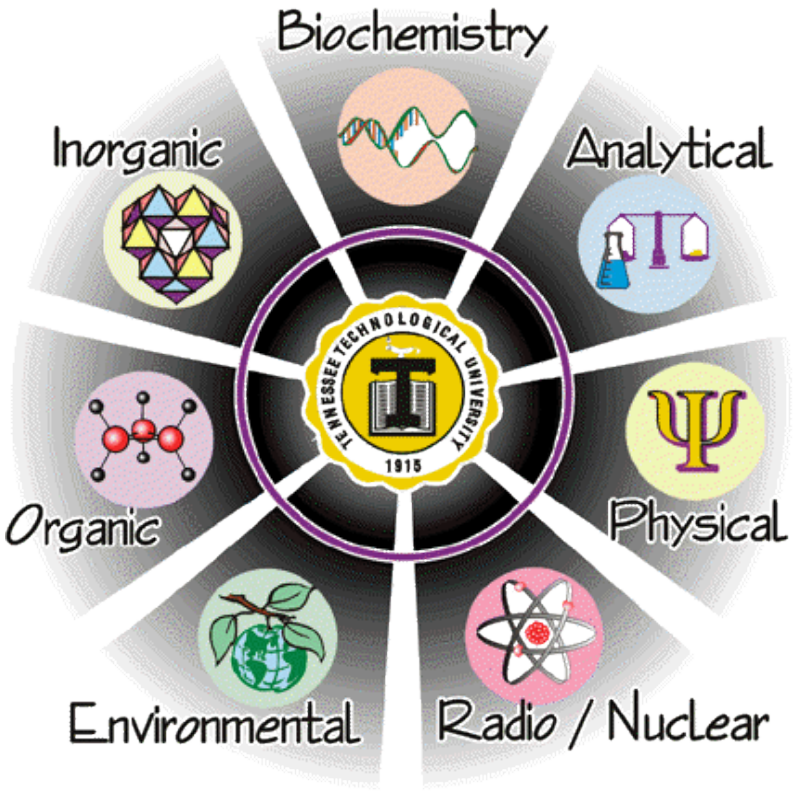
Handbook
for the
Master of Science (M.S.)
Degree Program in Chemistry
at
Tennessee Technological University



Fall 2018 Edition

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Mission of the Chemistry Graduate M.S. Program

The primary emphasis of the department is student learning. Faculty mentoring of independent student research is seen to play a key role in learning, and both undergraduate and graduate students are provided the facilities, opportunity, and inducement to be involved in original research. The department is also involved in community service through visiting local schools, science teacher enrichment workshops, and diverse activities to educate the general public about chemical science.

The specific mission of the graduate program in chemistry may be summarized as follows:

- To provide a program of study that prepares graduates to successfully pursue scientific careers in industry or to continue their education in a doctoral program or professional school.
- To provide students with opportunities to reinforce their background and expand their knowledge in areas not covered by their undergraduate degrees, with course offerings in the five major branches of chemistry.
- To provide a stimulating intellectual atmosphere conducive to the learning process of both students and faculty through low student-to-faculty ratios.
- To provide the facilities and professional mentorship enabling students to propose, conduct, evaluate, and report on original research and thereby add to the knowledge of humanity.
- To provide opportunities for students to refine both oral and written communication skills.

The graduate curriculum is designed to acquaint students with the current ideas in the five major areas of chemistry (organic, inorganic, physical, analytical and biochemical). The thesis project affords the student practical experience in the methods used to obtain new knowledge and to develop the skills necessary to understand and relate this knowledge. Special topics courses allow individual professors to present specialized material in their area of expertise. The faculty maintains a wide variety of research programs, giving each student an opportunity to conduct, evaluate, and report on original research.

Chemistry M.S. Student Learning Expectations

The Department of Chemistry has set specific goals for its students in the M.S. program. In fact, our faculty are expected to address these during their mentoring relationships with students.

Learning Outcome I:

Students should emerge from the M.S. Chemistry graduate program being able to use effectively the scientific method to solve chemical problems. Particularly, this includes (but is not limited to):

a) Being able to employ critical thinking skills to analyze a chemical problem,
b) Collect background information through the effective use of the scientific literature,
c) Prepare a hypothesis,
d) Design and execute experiments to test the hypothesis, keeping complete experimental records,
e) Apply appropriate statistical analysis to the data,
f) Apply critical thinking skills to further refine the hypothesis based on experimental evidence,
g) Effectively communicate the results through both oral and written communication skills.

Student success will be determined by the graduate student's thesis advisory committee at the time of oral defense of the written thesis.

Learning Outcome II:

Students should emerge from the M.S. Chemistry graduate program being able to effectively communicate scientific knowledge and ideas through both oral and written communication skills. Student success will be determined by the graduate student's thesis advisory committee at the time of oral defense of the written thesis.

Entrance Requirements

Any student that meets the following requirements can potentially be admitted to the M.S. program, subject to review by the Chemistry Graduate Committee and the needs of the department:

- an ACS-certified B.S. degree in Chemistry, or its equivalent;
- a combined (Verbal + Quantitative) score of 295 on the General GRE plus at least a 3.0 on the analytical writing portion;
- a grade point average of 2.5 or above on a 4.0 scale. A student with a GPA of 2.25 may be admitted to the program with provisional standing.
- For international applicants, proof of competency in written and spoken English is required. This may be demonstrated by scores on any of these standardized tests:

  TOEFL score of 83 (Internet-based), 220 (computer-based), or 557 (paper based) OR,
  IELTS score of 6.0 (overall band), OR,
  Achieve Level 8 in the English Language School.

Students with a non-ACS-certified degree or equivalent background can be admitted, subject to review by the Chemistry Graduate Committee, but may be required to enroll in specific graduate courses to strengthen their background in particular areas of chemistry. Graduate credit toward the M.S. degree may be earned by completing many of these courses. The normal background equivalent to ACS certification includes:

- One year each of general and organic chemistry
- Two semesters of physical chemistry – Chem 3500 (one-semester survey) or its equivalent may count as one of these semesters. The second semester of physical chemistry may be taken as graduate credit by enrolling in Chem 5970 – Special Topics "Quantum Chemistry".
- One semester each of quantitative analysis, inorganic and instrumental analysis
- One semester of calculus (required for physical chemistry)

Components of the MS Program

The MS program has two main requirements that are designed to help the student complete the Learning Objectives for the program: coursework requirements, and the research thesis.

Coursework Requirements:

The required courses are designed to give the student in-depth exposure to modern concepts across the different areas of chemistry. The student is expected to show skills and understanding in multiple areas. Coursework is also available to help the student master any deficiencies from their undergraduate program.

Students work with the academic advisor (program coordinator) to choose appropriate classes and complete the required paperwork in a timely fashion. The staff of the College of Graduate Studies will also help check paperwork and graduation requirements.

Coursework hours are typically taken during all four semesters of the typical 2-year degree program. This usually gives the student one or two courses per semester.

Research and Thesis:

The student will carry out an extended research project, working in collaboration with their chosen research advisor. The research project offers the student an opportunity to learn valuable skills in the methods of research, in professional and scientific conduct and in scientific communication. As part of the overall research project, the student will also write and defend a thesis of appropriate length and content.

The research advisor is the student's first point of contact for all questions related to the research process. The student will also choose other faculty to form their research committee (thesis committee); typically there are three faculty on the committee, including their research advisor as chair. The research advisor and the committee work together to help the student learn relevant skills, think deeply about their research work, and produce an acceptable thesis. The committee then serve as the final judges of the student's research work and the written thesis.

Work on the research project and thesis are expected to begin in the student's first semester. The student begins by selecting a research advisor, then working with the advisor to choose a specific topic or problem.

Advisement

Throughout a graduate student's career in the Chemistry Department at TTU, he or she works closely with the faculty in all areas of instruction and research. Initially, the student works with the *M.S. Graduate Student Advisor* to plan the first year of study. Once a *Research Advisor* and an *Advisory Committee* are chosen, they become his/her principal advising body. During the course of the student's program of study, the Graduate Student Advisor and his/her Research Advisor work closely to monitor the student's progress towards a degree.

The student's Advisory Committee, working with the Graduate Student Advisor, is responsible for approving the *Program of Study* and the research problem. A *Program of Study* in chemistry is designed to introduce the student to the major areas of specialization, either at the 6000 level or the 5000 level. Deficiencies in a student's background are identified before admission to the graduate program and additional courses from the undergraduate curriculum may be required. These courses are clearly identified on the admission certificate. The student's Advisory Committee should be composed of three members; two of which are closely related to the students chosen area of research and one of which could be any member or approved associate member of the graduate faculty.

The Master's degree in chemistry does not require that students take all courses within the department. Instead, students choose elective courses that best fit their chosen program of study. (In these cases they take elective courses in engineering, biology, computer science or chemistry.)

A thesis is required of all graduate students in the chemistry program. Each student, working with his/her Research Advisor and Advisory Committee, must identify a suitable problem and develop a plan of solution. Each graduate student has the opportunity to choose from a wide variety of research topics. Working closely with his/her Research Advisor, the student is afforded an opportunity for an in-depth experience in a field of specialization. The nature of laboratory research requires knowledge of statistical methods of data treatment and each student develops this ability during thesis research. Although no formal course work in computer technology or foreign language is required for the degree, a student is expected to use the computer for a variety of tasks including data treatment, graphics, and word processing. Non-credit courses freely offered by the computer center at TTU are strongly recommended for students with little or no experience in the use of computers.

Each graduate student is required to submit a written thesis for the approval by the Advisory Committee and the Graduate School. The defense of this thesis is an oral examination administered by the Advisory Committee and is open to the public. The University library retains two hardbound copies of the thesis, and the department and Research Advisor should each be afforded one copy. The Graduate Student Advisor retains copies of the student's records and transcripts are available from the University.

Course Requirements

The general requirement for the degree with research & thesis is 30 semester hours of credit. This includes 21 hours at the 6000 level, and 9 hours at the 5000 or 6000 level.

6000 Level

Required Courses

Chem 6900 – 1 hour - Directed Studies (The Research Plan/Proposal)
Chem 6910 – 1 hour – Literature Seminar (any topic in any chemical division)
Chem 6911 – 1 hour – Thesis Seminar
Chem 6990 – 6 hours – Thesis Research

Electives

Chem 6110 – 3 hours – Advanced Inorganic (offered every other Fall)
Chem 6410 – 3 hours – Advanced Analytical (offered every other Spring)
Chem 6610 – 3 hours – Advanced Biochemistry (offered every other Fall)
Chem 6210 – 3 hours – Advanced Organic (offered every other Spring)
Chem 6320 – 3 hours – Advanced Physical (offered every other Fall)
Chem 6350 – 3 hours – Advanced Molecular Modeling (offered every other Spring)
Chem 6970 – 3 hours – Advanced Special Topics (TBA)

5000 Level

Electives

*Chem 5110 – 3 hours – Inorganic (Spring)
*Chem 5520 – 4 hours – Instrumental Analysis (Fall)
Chem 5210 – 3 hours – Polymers (on demand – usually Fall)
Chem 5310 – 3 hours – Nuclear and Radiochemistry (every other Spring)
Chem 5320 – 3 hours – Spectroscopy (every other Spring)
Chem 5410 – 4 hours – Forensic Chemistry (Spring)
Chem 5610 – 3 hours – Biochemistry 1 (Fall)
Chem 5620 – 3 hours – Biochemistry 2 (Spring)
Chem 5650 – 2 hours – Biochemistry Laboratory (Spring)
Chem 5710 – 3 hours – Environmental Chemistry (every other Fall)
Chem 5720 – 3 hours – Advanced Environmental Chemistry (every other Spring)
Chem 5970 – 3 hours – Special Topics (on demand, Fall or Spring)

*Students that have not taken these courses or their equivalent at the undergraduate or graduate level will be required to complete these courses. This constitutes 7 of the 9 required hours at the 5000 level in the students *Program of Study*.

The *Program of Study* must be prepared by the student in consultation with their Graduate Advisory Committee by the mid-point of their second semester.

Advanced Course Offerings

FALL 2018	**SPRING 2019**
5000 – Graduate TA Training (1 s.h.)	5110 – Inorganic
5210 – Chemistry of Polymers	5320 – Organic Spectroscopy
5520 – Instrumental Analysis (4 s.h.)	5620 – Biochemistry II
5610 – Biochemistry I	6350 – Adv Molecular Modeling
6110 – Advanced Inorganic	6410 – Advanced Analytical
	EVS 7900 – Scientific Writing
	EVSC 6010 – Environmental Chemistry
FALL 2019	**SPRING 2020**
5000 – Graduate TA Training (1)	5110 – Inorganic Chemistry
5520 – Instrumental Analysis (4)	5310 – Radiochem
5610 – Biochemistry I	5410 – Forensic Chemistry (4)
5710 – Environmental I	5620 – Biochemistry II
6320 – Advanced Physical Chem	5720 – Environmental II
6610 – Advanced Biochem	6210 – Advanced Organic
EVSC 7110 – Water, Soil & Air Part 1	EVS 7900 – Scientific Writing
	EVSC 6010 – Environmental Chemistry

All classes are offered for 3 credit hours, unless otherwise indicated.

Course	Title	SH	Fall 18	Spring 19	Fall 19	Spring 20	Fall 20	Spring 21
5110	Inorganic Chemistry	3		X		X		
5150	Inorganic Chemistry Laboratory	1		X		X		
5210	Chemistry of Polymers	3	X				X	
5310	Nuclear Chem and Radiochemistry **	3				X		
5320	Spec Ident of Organic Compounds **	3		X				X
5410	Forensic Chemistry **	4				X		
5520	Instrumental Analysis **	4	X		X		X	
5610	Biochemistry I	3	X	X	X	X	X	X
5620	Biochemistry II	3		X		X		X
5650	Biochemistry Laboratory	2	X	X	X	X	X	X
5710	Environmental Chemistry	3			X			
5720	Advanced Environmental Chemistry	3				X		
5970	Special Topics	TBD						
5000	Graduate Teaching Assistant Training	1	X		X		X	
6110	Advanced Inorganic Chemistry	3	X				X	
6210	Advanced Organic Chemistry	3				X		
6320	Advanced Physical Chemistry	3			X			
6350	Advanced Molecular Modeling	3		X				X
6410	Advanced Analytical Chemistry	3		X				X
6610	Advanced Biochemistry	3			X			
6970	Advanced Special Topics	3						

Graduate Program Guidelines

Seminars

Attendance at all chemistry department seminars is required of all graduate students. Students should maintain professional conduct. Pay attention to the speaker, avoiding the use of electronic devices. Asking questions is a good way to show engagement. Cell phones should be silenced. Treat speakers politely, as colleagues or possible employers.

All graduate students will give two seminars as they complete their degree requirements – the Literature Seminar (typically second semester) and the Thesis Seminar (final semester).

Students who do not give their Literature Seminar in the semester in which they enroll in the class, but instead receive an Incomplete, can only receive a grade of B or below when they make up their Incomplete.

Teaching Assistantships

TTU policy on Graduate T.A. appointments and responsibilities is described in Policy #274 and #276. This section describes more specific expectations from the Chemistry department.

Students being supported by a T.A. will be required to be available to assist in the proctoring of evening exams and final exams, at the discretion of the Chemistry Chair.

Support on a T.A. is limited to four semesters (not including summers). The only exception to this rule should be for dire circumstances (such as medical incapacity). It is the responsibility of both the student and the research advisor to insure that progress is made toward timely graduation.

Development as a T.A. is an important part of a graduate student's overall development as a professional scientist. T.A.s are regularly evaluated for performance. Unacceptable performance may lead to loss of financial support as a T.A.

Please see also the later section on "Graduate Teaching Assistant Professionalism".

Conduct of Research

All research students must complete appropriate safety training before beginning work in a laboratory, as determined by the TTU Office of Environmental Health & Safety. The research advisor (P.I.) for a particular lab is responsible for providing site-specific training and confirming that the student has completed the required online training modules. Students who carry out work in ways that are not compliant with current safety guidance may be required to immediately cease work and may face additional sanctions.

As chemical professionals in training, all M.S. students are expected to read, and work to

follow, the ethical standards of the American Chemical Society. Relevant material may be found on the website Ethics CORE: https://nationalethicscenter.org/societies/acs.

M.S. students must maintain a current *Laboratory Notebook* that needs to be available for review at any time, but especially during the Chem 6900 proposal presentation and thesis defense. The notebook is to be given over to the Research Advisor at the conclusion of the program. Students should consult their own Research Advisor or committee for advice regarding what form this notebook should take (electronic, bound, 3-ring loose bound, etc.).

Some research advisors or student advisory committees may require additional *Progress Reports* to be submitted at intervals to be determined at the discretion of the committee.

Presentations & Publications

Students are required to give at least one research presentation at a professional meeting, such as TTU Student Research Day, TAS meetings, ACS meetings, etc. This could be either an oral or a poster presentation. Presentation at larger conferences in your field are more helpful to your professional career, and can lead to important connections for future employment, admission to PhD programs or other research opportunities.

Students are strongly encouraged to work with their research advisor to publish their research in a scientific journal. Work that isn't made public is of limited value to the world, and scientific progress relies on the process of peer review for assessing a work's merit. Publications are especially important for students applying to PhD programs and for those interested in an academic career.

Remedial Coursework

Depending on individual students' needs to remedy background deficiencies, students may be required to informally audit undergraduate classes. This requirement could be made by the M.S. Program Advisor, the Research Advisor, or the Advisory Committee. The Faculty Lab Coordinator can also require this of graduate T.A.s for the class related to the lab being taught.

Graduation Requirements and Degree Completion

The faculty and staff do their best to track deadline dates imposed by the College of Graduate Studies (available on its website), and to stay up to date on any changes to rules, policy and thesis guidelines. Nevertheless, the primary responsibility for this information rests with the graduate students. Particularly in your final semester, you are required to download the Graduate Studies' manual for thesis preparation, which includes very detailed notes on how things must be formatted.

Following the rules and guidelines for the content and formatting of the thesis is critical to the final acceptance of the thesis by the committee and the College of Graduate Studies.

Special Topics Courses

The coursework of the MS Chemistry program is designed to support your training with both breadth and depth. From time to time, a student may need, or a faculty member may decide to offer, a course beyond the established curriculum published in this handbook and in the Graduate Catalog. These "Special Topics" classes may be taken for 1 to 4 hours of credit, although 3 hours credit is most typical. Students will typically take Special Topics classes offered by their own research advisor, although in some cases a Special Topics class may have broad appeal to students in other research groups.

Special Topics classes are offered as CHEM 5970 and as CHEM 6970 (as "Advanced Special Topics").

CHEM 5970 and CHEM 6970 may be used to fill coursework requirements at either the 5000 or the 6000 level, as appropriate. Students may take both CHEM 5970 and CHEM 6970 as needed. When taking several Special Topics classes, it should be clear to the student, their advisor, their thesis committee, and the University that the classes are substantially different.

All CHEM 5970 and CHEM 6970 classes require instructor consent, the approval of the MS Program Coordinator, and the department chair.

Advanced undergraduates may also enroll in CHEM 5970 by instructor consent.

The only recurring 5970 class is "Special Topics in Quantum Chemistry," designed to supplement incoming students' knowledge of physical chemistry.

Program Timeline

The following provides a set of milestones expected for a full-time graduate student being supported on a teaching assistantship. These have been set up by the Chemistry Department to keep the student progressing through the program to successful matriculation in a timely fashion. Exceptions to these milestones can be made only by approval of the Chemistry M.S. Oversight Committee.

Failure to make a good-faith effort to fulfill these milestones will result in the loss of the teaching assistantship.

- First Semester – Faculty Interviews – Student must interview a minimum of five faculty members and turn in the *Interview Sheet* to the Graduate Student Advisor by the end of the 6th week of their first semester. This will include the selection of the top three ranked choices of a Research Advisor.

- Second Semester – Program of Study. The student, in consultation with their Research Advisor, must complete a *Program of Study* form signed by their chosen committee and the Chemistry Department Chair and file it with the Graduate School. This must be done within the first 6 weeks of the second semester. A hold is placed on a student's registration if this form is not filed after completion of 15 hours of graduate study.
- Second Semester – Directed Studies (Chem 6900). Students are encouraged to complete this course requirement as early as possible, but must do so no later than the end of their second semester.
- Second Semester – Literature Seminar (Chem 6910). Students must prepare and present a seminar (in consultation with the Seminar Coordinator and their Research Advisor) on any area of chemistry except that which directly involves their thesis topic. This will be presented to their peers and their Graduate Advisory Committee in the Thursday afternoon seminar series. Students who fail to give their Literature Seminar in the semester in which they enroll in it but instead receive an Incomplete, can only receive a grade of B or below when they make up their Incomplete.

- Last Semester – Second Graduate Seminar (Chem 6911) – Students must prepare and present a Friday afternoon departmental seminar (in consultation with the Seminar Coordinator and their Research Advisor) that adequately covers their thesis research. This is expected to take place in the Third or Fourth Semester, and is usually scheduled in conjunction with the thesis defense.
- Last Semester – Application for graduation is required (no exceptions) by the end of the first week of the semester that the student plans to graduate. Consult the Graduate School office for important dates such as 1) last day to complete thesis defense, 2) last day to submit preliminary copy of thesis and 3) last day to apply for graduation.

TTU Fast-Track M.S. Program in Chemistry (4+1)

This is a "4+1" program designed for students in the TTU ACS-certified B.S. chemistry concentration to provide a fast route to an M.S. degree, typically requiring an additional year beyond the B.S. degree.

Advantages:

- Once accepted into Fast Track, a Teaching Assistantship is reserved for you for your graduate year.
- Research performed with your faculty mentor as an undergraduate carries forward into your thesis research.
- Work on two degrees at once within a normal course load.
- Fast route to an advanced degree giving you marketable skills.
- Strengthens academic background for entry into Professional School or PhD program.
- Up to 6 hours of dual credit can be earned your senior year. These hours count toward both your B.S. and M.S. degrees.

For ACS Chemistry Majors:

This program is designed for an ACS chemistry major to begin their senior year. A fast-track senior may take 9 hours of graduate-level coursework (5000- or 6000- level, e.g. take Chem 5110 versus 4110) and have 6 of these hours ***also*** count toward their undergraduate degree.

Example schedule: (5000 and 6000 designate elective coursework approved by dept.)

Senior Year		Summer	Graduate Year		Summer
Fall	***Spring***		*Fall*	*Spring*	
Chem 5000*	Chem 6000	Chem 6900	Chem 6910	Chem 6911	Chem 6990
	Chem 5000*		Chem6000	Chem 6000	
			Chem6000	Chem 5000	
			Chem6990	Chem 6990	
3 s.h.	**6 s.h.**	**1 s.h.**	**10 s.h.**	**9 s.h.**	**+ 1 s.h. = 30 s.h.**

*Up to 6 hours of credit can be counted toward **both** the undergraduate and graduate degree.

For Non-ACS majors:

Non-ACS majors with coursework that satisfies the admissions requirements may also be admitted. Students who haven't previously been working toward the ACS requirements should start discussing the FT program with their undergraduate advisor and the graduate advisor in their sophomore year, or as early as possible in their junior year. This gives more time for any additional coursework to be taken. This additional coursework will minimize any bumps along the way to the MS and to maximize your research effectiveness.

Transfer Students:

Transfer students will be evaluated on a case-by-case basis.

Admission:

- Subject to approval by the Chair and the Chemistry Graduate Committee.
- Overall QPA = 2.8 or above, 3.0 or above in upper division chemistry courses.
- Application is allowed once Junior Standing is earned.
- Can begin Fast-Track program as a Senior.
- Final B.S. must include a minimum of:
    - Two semesters of calculus,
    - Two semesters **each** of general, organic, and physical chemistry,
    - One semester **each** of analytical chemistry and biochemistry.
- Entrance to the Fast-Track Program can be granted if the student has met the above requirements for calculus, general, organic and physical chemistry.

Undergraduates taking courses for graduate credit are billed at the undergraduate rate.

Other TTU Chemistry Undergraduates:

TTU seniors who do not fully qualify for the FT program but who plan to seek a M.S. Chemistry degree at TTU may also take up to 9 graduate-level coursework hours as a senior. Subject to instructor approval, these hours can include 5000- or 6000-level chemistry courses. Up to 6 hours of this graduate coursework taken during the senior year can be used to satisfy both undergraduate and graduate degree requirements.

The work taken at the graduate level *may* be used to satisfy coursework requirements at the graduate level. This is subject to approval from the student's research advisor and thesis committee.

While having taken graduate coursework as an undergraduate *may* decrease your time to degree after starting the MS program, there is no automatic expectation that you will finish your MS degree within one year after completing your BS degree.

Chemistry Graduate Course Descriptions

CHEM 4110 (5110). Inorganic Chemistry - Spring. Lec. 3, Credit 3. Prerequisite: CHEM 2010 and CHEM 3500 or 3510. Correlation of physical and chemical properties of inorganic compounds and atomic structure.

CHEM 4150 (5150). Inorganic Chemistry Laboratory. Lab. 3, Credit 1. Corequisite: CHEM 4110. Synthesis, isolation, and characterization of inorganic compounds, using conventional as well as microscale and inert gas techniques.

CHEM 4210 (5210). Chemistry of Polymers - Fall. Lec. 3, Credit 3. Prerequisites: CHEM 3120, 3520. Preparation, structure, and physical and chemical properties of organic and inorganic polymers. Viscoelastic behavior and processing technology.

CHEM 4310 (5310). Nuclear and Radiochemistry - Spring. Lec. 2, Lab. 3, Credit 3. Prerequisite: CHEM 3500 or 3510 (may be taken concurrently). Introduction to theory of nuclear stability and decay processes. The laboratory emphasizes the detection, safe handling, and use of radioisotopes in chemical investigations.

CHEM 4320 (5320). Spectrometric Identification of Organic Compounds - Spring. Lec. 2, Lab. 3, Credit 3. Prerequisites: CHEM 3020 and CHEM 3500 or 3510. The isolation and identification of organic compounds by both chemical and physical means with emphasis on spectroscopic methods.

CHEM 4410 (5410) Forensic Chemistry – Spring. Lec 3, Lab 1, Credit 4. Prerequisites: CHEM 1120, 3020 and 3410. This course will examine the application of chemical concepts and methods to the analysis of crime scene evidence.

CHEM 4520 (5520). Instrumental Analysis - Fall. Lec. 3, Lab. 3, Credit 4. Prerequisites: CHEM 3410 and 3510. Theory and practice of atomic spectroscopy, chromatography, and electroanalysis; discussion of selected instrumental techniques for analysis of surfaces, molecules, and particles.

CHEM 4610 (5610). General Biochemistry - Fall. Lec. 3, Credit 3. Prerequisite: CHEM 3005 or 3010. Chemistry of proteins, lipids, carbohydrates, and nucleic acids. Includes study of pH, buffer system and biological separation methods.

CHEM 4620 (5620). General Biochemistry - Spring. Lec. 3, Credit 3. Prerequisite: CHEM 4610. Intermediary metabolism, bioenergetics, biosynthesis.

CHEM 4650 (5650). General Biochemistry Laboratory - Spring. Lab. 6, Credit 2. Prerequisite: CHEM 4610 (5610) General Biochemistry or concurrent enrollment. Laboratory techniques associated with contemporary general biochemistry to include buffer preparation, pKa determination, amino acid analysis, protein expression, separation and purification techniques, protein determination, enzymology, equilibrium and binding

constant determination and carbohydrate analysis. The CHEM 5650 student will engage in additional procedures in some of the experiments.

CHEM 4710 (5710). Environmental Chemistry – Fall. Lec. 3, Credit 3. Prerequisite: CHEM 33005 or 3010, and CHEM 3410, 3500 or 3510 (courses from the latter group may be taken concurrently). Basic concepts of environmental chemistry.

CHEM 4720 (5720). Advanced Environmental Chemistry. Lec. 2, Lab. 3, Credit 3. Prerequisite: CHEM 4710. Advanced topics within environmental chemistry, including emphasis on organic, inorganic and analytical environmental chemistry. Case studies and contemporary literature in the field will be discussed. CHEM 5720 students will be required to carry out a more extensive field project and present a paper on an advanced topic in environmental chemistry.

CHEM 4970 (5970). Special Topics. Lec. 1-3, Lab. 0-3, Credit 1-4. Prerequisite: Consent of instructor. Timely topics in chemistry. Course may be taken for credit more than once.

CHEM 6110. Advanced Inorganic Chemistry - Fall. Lec. 3, Credit 3. Prerequisite: CHEM 4110. The correlation of the physical and chemical properties of inorganic compounds with their structure.

CHEM 6210. Advanced Organic Chemistry - Spring. Lec. 3, Credit 3. Prerequisite: CHEM 3020. Application of physical principles to the understanding of the structure and dynamics of organic compounds.

CHEM 6320. Advanced Physical Chemistry - Fall. Lec. 3, Credit 3. Prerequisite: CHEM 3520. Advanced topics in physical chemistry to include aspects of statistical thermodynamics, quantum mechanics, spectroscopy, and kinetics.

CHEM 6350. Advanced Molecular Modeling – Spring. Lec. 3, Credit 3. Prerequisite: CHEM 3510 or equivalent and consent of instructor. Molecular graphics and visualization, computational quantum chemistry for molecular structure prediction, molecular mechanics force fields and their application, molecular dynamics simulations, QSAR, biochemical macromolecule and analysis.

CHEM 6410. Advanced Analytical Chemistry - Spring. Lec. 2, Lab. 3, Credit 3. Prerequisite: CHEM 4520. Statistical interpretation of data; electronics of instrumentation; optimization of chromatographic methods; recent developments in spectroscopy, chromatography, and mass spectrometry.

CHEM 6610. Advanced Biochemistry – Fall. Lec. 3, Credit 3. Prerequisites: CHEM 4610(5610). Current advanced topics in Biochemistry selected from recent peer-reviewed literary journals. Instruction, with practical exercises, in the step-by-step stages of grant planning, locating funding sources, and writing successful grant proposals.

CHEM 6900. Directed Studies in Chemistry. Lec. 1, Credit 1. Prerequisite: Graduate standing in chemistry. Investigation of a current area of research which is compatible with the student¹s interest and abilities. (Maximum credit toward degree is one hour.)

CHEM 6910. Chemistry Literature Seminar. Lec. 1, Credit 1. Prerequisite: Consent of thesis advisor. Review and oral presentation of current topic in the chemical literature. (Maximum credit toward degree is one hour.)

CHEM 6911. Chemistry Thesis Seminar. Lec. 1, Credit 1. Prerequisite: Full standing in chemistry M.S. program, and consent of thesis advisor. Oral presentation of student's thesis research. (Maximum credit toward degree is one hour.)

CHEM 6970. Advanced Special Topics in Chemistry. Lec. 1-3, Lab. 0-3, Credit 1-4. Prerequisite: Consent of Instructor. An advanced course for current topics in chemistry. Course may be taken for credit more than once.

CHEM 6990. Research and Thesis. Credit 1-9.

Miscellaneous Important Facts

MINIMUM FULL LOADS:

- U.S. Students must be enrolled in a minimum of 6 credit hours to be a TA, and 9 hours if getting financial aid.
- International students must be enrolled in a minimum of 9 credit hours to keep their I-20 (Visa) in proper status.
- There is no load requirement in summer term, but students who are being supported as a TA during the summer must be registered for a class – this can include 6990, Research & Thesis.
- Last semester international students may take just 1 hour for immigration, but if on a TA, must have a minimum of 6 hours.

International students need to file Form 8233 in Payroll to claim exemption from withholding if their country has a Tax Treaty with the US.

International students may only work 20 hours/week in this country, and being on a full TA constitutes 20 hours/week.

A student must be enrolled in a course the semester they will graduate, unless they complete all their requirements (turn in thesis, etc.) by the end of registration for that term.

A student must apply for graduation in the first week of the semester in which they expect to graduate, no exceptions.

A graduate student does NOT need to be enrolled for credit in Summer to be paid on a research grant.

Building keys are issued by Tammie Hanchey, the Stockroom Manager, whose office is the Stockroom on third floor. Graduate students are issued a front door key to Foster Hall, a laboratory pass key, and sometimes instrument room keys. Keys to research labs are issued by the faculty member in charge. Keys issued to a student must be returned as part of departure from the program – no exceptions.

All forms and memorandums required for graduation must be filed in the Graduate School Office no later than one (1) week prior to commencement, with the exception of the defense form and comprehensive exam form which are due three (3) weeks prior to commencement. Transcripts from other universities used as transfer credit on a program of study must be received no later than two (2) weeks after the commencement date.

The advisory committee-approved copy of the thesis/dissertation must be submitted through the eTD Administrator (ProQuest) for format review no later than two (2) weeks prior to commencement. It is advisable that the student make an appointment with a Graduate School staff member for format review consultation. The final copy for publication through ProQuest must be submitted via the eTD Administrator one (1) week prior to commencement.

Finding and Managing Articles and Other References

As you work on your research, you will learn to access the scientific literature and search it effectively to find the material you need. As you write your thesis, you'll also need to keep track of papers and books you've used, to cite it in your written work, and to format your reference list into a proper bibliography. **The TTU Library can help with all of this!**

Searching the Literature

For literature searches, the two most popular options available at Tech are SciFinder Scholar, and Google Scholar. The Library's own "Eagle Search" also includes journal articles, and finding material through the library's site makes it very simple to see how the library can provide access. Your research advisor probably has strong views about which tools to use; **always start with what your advisor prefers.**

SciFinder® is your portal to chemistry and related information providing easy access to the most trusted collection of chemical substances, reactions and literature references in the world curated by expert scientists, not robots. Leading pharmaceutical and chemical corporations as well as top academic institutions and government labs rely on SciFinder to keep up to date on and leverage the latest advances in science.

You can search for substances, reactions, and patent and journal references, including abstracts and links to full-text articles from over 10,000 professional and peer-reviewed journals; as well as collections of patent information and other documents. You may search for research topic by phase, author, or company name; or search for chemical substance information by chemical structure or names, CAS registry number molecular formula, or reaction structure.

Familiarity with SciFinder is typically expected of MS Chemistry graduates. You should invest some time in making sure that you have developed this skill!

How to Register & Access the Web Version of SciFinder

Each student or faculty will need to register to use the web version of SciFinder. The current procedure for registration with SciFinder is available through the library at https://www.tntech.edu/library/research/how-to-search.

Once you register, the login page can be reached – only from TTU campus - at:

https://scifinder.cas.org/scifinder/login.

Simultaneous Users:

- There can be 8 users of SciFinder Scholar at once.

- If there are already 8 people using SciFinder Scholar Web Version, when the 9th person attempts to log in, they will see a message that says “"All allocated system resources are in use"
- Also, if a searcher just exits the browser, rather than clicking the Log-Off link in SciFinder, SciFinder will preserve that active session for 20 minutes and then terminate the session and re-set the concurrent use counter.

Obtaining articles

The TTU Library subscribes to more than 400 journals in electronic format, and has access to thousands more. Once you’ve found the article through SciFinder Scholar or Google Scholar, you can use “Eagle Search” (search by title, or author and title) to see how the library can provide access. In some cases, you can also go directly to the journal’s website to download the article. TTU provides full access to all ACS journals. For legal reasons, access is restricted to users on TTU campus; if you’re connecting off campus, you need to prove your right to access the material with your TTU username and password.

If you proceed to download the full text of an article that is not in the TTU Library Collection, you will be given two choices to acquire the article:

- Interlibrary Loan (this is a simple online form that gains you usually an electronic file of your article within 2 or 3 days). This service is free.

- Get It Now. This costs the TTU Library money, and is only used when you absolutely need to have the article right now.

Organizing your References

As you conduct your research, you’ll come across dozens, even hundreds, of articles that are relevant to your project. It becomes a difficult task to keep that material organized. As you write your thesis, you’ll need to cite the resources from which you obtained information. This is usually done through “inline” citations in the text, followed by a bibliography at the end of the work. These must be formatted correctly for the kind of work you’re writing – even different journals have different formatting requirements. As you write and edit your work, the order of references will also change. Keeping up with this by hand used to be a significant problem for students writing theses and dissertations – including your professors when they were your age.

The modern solution is to use software that can keep track of the reference information, insert it into the proper place in your document, and format the bibliography and citations correctly for your purpose. Some popular options include EndNote, Mendeley, Zotero, ACS ChemWorx, Papers (for you Mac users) and RefWorks. The TTU Library provides all TTU faculty and students with RefWorks access, so this powerful option is available to you at no cost.

The RefWorks website can store bibliographic information (title, author, journal, dates, pages, as well as the abstract and any private notes you want to add) on an unlimited number of journal articles, conference presentations, technical whitepapers, patents, books and book chapters. You can then search this "personal library" for the papers you've already found on a particular topic, making it easy to remember which source you got particular information from.

RefWorks also has a "Write'n'Cite" plugin (add-on software) for Microsoft Word, which you can download and install on your own computer. (It may already be installed on most campus computers also.) This plugin lets you access your "personal library" from within Word, so that you can insert a citation in the right spot with just a few clicks of the mouse. When you are ready to format your bibliography, the plugin will add or update your bibliography with all of the correct information in the proper format, keeping the references in proper order.

The Library offers training in RefWorks.

Chemistry 6900 – Directed Studies in Chemistry (Research Proposal)

This one-hour course is designed for first-year graduate students after they have selected their Research Advisor, and is typically taken in the student's second term.

The purpose of this course is to involve a student's Thesis Advisory Committee more directly in the choice of the student's research problem. There are two components to this course.

The details of this course are left to the discretion of the Research Advisor and the committee. The intent is to involve the committee at an earlier point in the research so that they can serve as a resource for the student. It will also give a student a good start on writing the introduction for the thesis.

- As soon as a professor accepts the student and becomes the student's research advisor, he or she should assign a literature review of the important background material in the general area of the student's problem. This should give the student a better understanding of the reason for the research. This review project typically begins during the first semester.

- During the term in which Chem 6900 is taken, the student (in consultation with the Research Advisor) should write a brief literature review and project proposal.

- The details of the contents of the proposal are at the discretion of the research advisor. A satisfactory proposal typically includes a clear statement of the goals or questions the research is designed to address, a summary of the relevant background from the literature, and a plan of action for how the goals are to be accomplished. References are required. "Preliminary data" from work that the student has already carried out during the process of writing the proposal is welcomed and appropriate, but not required by the department. The total length for a satisfactory proposal might be between 15 and 25 pages.

- This proposal should be given to each committee member **at least one week** prior to a defense meeting where the student will answer questions about the proposal. Committee members might prefer a paper copy or an electronic copy. Both should be provided by the student.

- By department policy, the proposal defense must be completed no later than the end of finals week, during the semester in which the student takes CHEM 6900. (Earlier is generally more convenient for faculty and for the student.) Students who do not complete their proposal defense are at risk of losing financial support from the department.

A letter grade is given by the Thesis Advisory Committee.

Pay Schedule for Graduate Assistants

Total salary, monthly salary and number of paychecks:

a) For the Fall semester, there will be 4 full-month paychecks, at the end of September, October, November, and December. For example, if your normal total stipend for a full assistantship for one semester is $4,800 (half of $9,600), then the monthly salary is $1,200 ($4,800/4 = $1,200).

b) For the Spring semester, there will be 4 full-month paychecks – at the end of January, February, March, and April. For example, if your normal total stipend for a full assistantship for one semester is $4,800 (half of $9,600), then the monthly salary is $1,200 ($4,800/4 = $1,200).

Notice that your first pay check in the fall semester is at the end of September; you do not get paid in August for the regular academic year. (After all, your TA duties don't really begin until September. Most jobs pay based on work you've already done, not work you're planning on doing.)

Graduate Teaching Assistant Professionalism

As a graduate teaching assistant in the Department of Chemistry you are considered a fellow colleague of the faculty, and play a vital role in our educational mission. We appreciate your conscientious efforts in helping us as teaching assistants in our laboratories and the commitment and dedication you show to our students. Certainly the stipend we are able to give you is not nearly what you are worth to us.

You are at a critical point in your career as chemists - the transition from being a student to being a professional. As such it is important for you to begin to change the way you think about yourself. You are not simply a student anymore. For example, it is important for you to be more *accessible*, not only to your students, but to your faculty colleagues as well, who depend on you to turn in grades in a timely fashion, and be available for consultation in matters related to grades. This is especially crucial during finals week when grades are being determined, adjusted, and questioned by students. Accessibility includes not only your physical presence, but *checking your mailbox* in the main office daily, checking and answering your *email*, and so forth. You should not simply disappear into the woodwork on the last day of class only to re-emerge on the first day of the next semester.

Since you are on a stipend, you should plan to be here in August and January several days in advance of the first day of class, working on your research projects, and helping the faculty supervisors of laboratories get the labs ready for the coming semester if needed. Obviously we don't have anyone punching a time clock, and we are very flexible about hours. But no one, faculty, staff, or TA's, should take this liberty as license.

Another aspect of being a graduate student is that grades are not nearly as important as they are to younger students. It is not simply the A you get in a class that will count in your future. The *impression* you make on your research advisor and other faculty is more important. Future employers want to know how *responsible* and *reliable* you are, and about whether you work well in teams. If you don't work well with others, it will hurt your chances of succeeding in your work environment. No one is an island. We are here to help guide you into your future career, and we would be remiss not to make mention of these kinds of things.

Thanks again for all your efforts. We are proud of every one of you.

Scott H. Northrup
M.S. Program Advisor

Gene Mullins
Assistant Laboratory Coordinator

Student Research Development Grant

Introduction: The Student Research Development Grant program was established in the Fall 2009 semester to stimulate student research in the Department of Chemistry at Tennessee Tech University. The financial support of the Student Research Development Grant is mainly derived from selling in-house published laboratory manuals and class notes as well as other sources.

Oversight Committee: The Student Research Development Grant program is managed by the Student Research Development Committee. The committee evaluates the grant proposals based on their scientific merit, organization, clarity, and budget.

Eligibility: The grant is open to current Tennessee Tech students carrying out research with a faculty member in the Chemistry Department. Although the grant is open to both undergraduate and graduate students, priority will be given to proposals from undergraduate students.

Application Process: The application package needs to include the materials listed below.

The materials should be combined into one single PDF file, and submitted via email directly to Dr. Bill Carroll (WCarroll@tntech.edu), no later than 5:00 p.m. on the day of the deadline. The copier in the Chemistry office (FH 219) can accomplish this, including scanning in all printed materials; various software packages can also be used.

Required materials:

- Proposal (a minimum of 1000 words, double-spaced, font size of 12 or higher). The overall format for the proposal is open, but it should contain sections like: Introduction (or Background), Objective, Methodology, Project Description (or Research Plan), Summary, etc. The proposal should also highlight student's prior research experience/results (if any).
- Budget Form (downloadable from the TTU Chemistry website).
- Note: A "mentor approval form" was formerly required, but is no longer required.

In order to be considered, the application packages should be received in the Chemistry Department main office before the deadline.

Application Deadline: The grant generally has two deadlines: 12:00 noon of the first Monday of October for Fall and Spring semesters, and 12:00 noon of the first Monday of March for Spring and Summer semesters. Flyers posted around the department will give specific dates for each proposal cycle.

Grant Amount: There is no maximum amount set for the grant at this time but a typical amount is expected to be between $500 and $1500. Higher amounts will be considered but they will have to be properly justified in the proposal. The faculty mentor will manage the

funds. Grant money unused within nine months of the award will be forfeited unless the Department Chair grants a special approval.

Final Report: At the end of the research project, the student should prepare a report (a minimum of 1000 words, doubled-spaced, font size of 12 or higher) in a publishable format (see ACS-style guide) and submit it electronically to the Chemistry Department Chair. This report should include statements on how the money was used and how it enhanced their research experience.

Dissemination of student research in a scientific setting (TTU Student Research Day, ACS national or regional meeting, TTU Chemistry Department seminar, etc.) is expected.

Graduate Student Travel Fund

Purpose: to support travel of graduate students to conferences and professional meetings to present the results of their research or to participate in professional activities that enhance the visibility of our graduate programs.

Amount of Awards: up to $400 per proposal for eligible graduate students, with a maximum of 1 award per student, per academic year. The total amount available in the fund is $2000.

Eligibility: applicants must be enrolled graduate students majoring in one of the CAS programs (Biology MS, Chemistry MS, Computer Science MS, English MA, Environmental Science PhD or Mathematics MS).

Application Process:
Applicant (graduate student) sends to the department chair via his/her advisor a 1-2 page proposal (no more than 500 words including budget and factual details) that includes:

- Name, location, and date(s) of the activity
- Explanation of how the activity will benefit the academic program
- Estimated costs, including, as a minimum, registration, transportation, and lodging
- Extent of support from other sources (e.g., external funds from grants or contracts, departmental funds, TTU Chapter 606 funds, etc.)
- Indication of whether or not partial funding would be accepted.

Department Chair forwards the application(s) to the Dean's office, along with a one-page letter of support that includes comments on (a) the proposed activity's potential benefit to the academic program and (b) the availability of alternate funding sources. If there is more than one application from the department, the chair ranks them.

Deadlines for Submission to the Dean's Office: 1 September, 1 December, 1 March, and 1 May (by noon the following Monday if the 1st falls on a weekend) of each year.

Screening Committee: The applications will be screened and awards recommended to the Dean by the CAS Faculty Development Committee.

Criteria: Proposals will be ranked consistent with the stated purpose of the fund ("to support travel of graduate students to conferences and professional meetings to present the results of their research or to participate in professional activities that enhance the visibility of our graduate programs"), with student presentation of papers given top priority. Regarding proposals considered equal in all other respects, preference will given to those by students who have no other available source of travel support.

Limits on Frequency of Applications and Awards: (1) The same proposal may be resubmitted no more than once in a 12-month period. (2) A graduate student may receive no more than one award in a fiscal year, whether or not the $400 maximum is met in that one award.

Accountability: Within a month after the activity is concluded, each awardee will send to the Dean a 1-2 page report evaluating the experience and explaining how the results will be disseminated to colleagues.

Interviews with Faculty
Selection of Research Advisor Choices

During your first six weeks as a graduate student in the M.S. Chemistry Program, you should select a Research Advisor. Don't take this choice lightly. Try to select someone that you believe will (1) be a good mentor to you in research and professional development, and (2) help you work on an interesting and challenging research project.

You need to talk to at least five chemistry faculty about their research programs. These **must** include some of those faculty who gave a research presentation at the Research Mini-Symposium, held the first few weeks of your first semester.

To assist you with this process, this signature form should be taken to each of your faculty interviews. After each interview, have the faculty member sign this form. After you have obtained a minimum of five signatures, you should then rank your choice for a research advisor (1^{st}, 2^{nd}, 3^{rd}).

This form must be returned to Dr. Callender by the end of the sixth week of your first semester.

(signed)	(date)	(signed)	(date)
(signed)	(date)	(signed)	(date)
(signed)	(date)	(signed)	(date)

First choice: _____

Second choice: _____

Third choice: _____

Your name and signature: _____

Proposed Course of Study Grid

Student: _____

FALL 2018	SPRING 2019	SUMMER 2019
FALL 2019	**SPRING 2020**	**SUMMER 2020**
FALL 2020	**SPRING 2021**	**SUMMER 2021**

Notes:

5x (9 sh)	6x (4)	Program
		☐ 6900 ☐ 6910 ☐ 6911 ☐ 6990 _____

Chem 6910 (Literature Seminar) Evaluation Form

NAME OF PRESENTER:	Evaluator: ___faculty ___Graduate student ___Undergraduate ___other

Please check the categories where improvement could be made. Include any clarifying comments.

Planning and preparation				***COMMENTS***
Abstract clear, succinct, and outline				
adequate detail in abstract				
adequate detail in outline				
Did the speaker adhere to the outline?				
OTHER:				
Presentation to audience:				
Voice level and clarity		*correct grammar*		
Enthusiasm		*Timing/ pacing*		
eye contact		*well-organized*		
absence of annoying actions		*professional demeanor*		
proper use of notes				
OTHER:				
Visual Aids: *relevance*				
effective use				
Quality				
correct grammar and spelling				
proper use of equipment				
proper citations				
OTHER:				
Subject matter: *Knowledge about subject*				
presentation of scientific merit				
use of literature				
thorough understanding of material				
OTHER				
Discussion				
Interest aroused				
ability to answer questions				
adequate time allowed for questions				
OTHER				

GENERAL COMMENTS

Thesis Defense Assessment Rubric

Student: _____ Defense date:_____ Today's date: _____

Reviewer:_____ Reviewer role: Chair Committee Other: _____

* Point Value	4	3	2	1
Thesis Problem or Question	Student contributed to thoughtful, creative hypotheses that engaged them in challenging or provocative research. The research breaks new ground or contributes to knowledge in a focused, specific area.	Student contributed to focused hypotheses involving them in challenging research.	Student contributed little to the hypothesis. Contributions by student lend to readily available answers.	Student relied solely on faculty-generated hypotheses or developed a hypothesis requiring little creative thought.
Information Seeking, Selecting and Evaluating	Student gathered information from a variety of quality electronic and print sources, including appropriate databases. Sources are relevant, balanced and include critical information relating to the thesis or problem. Primary sources were included.	Student gathered information from a variety of relevant sources--print and electronic. Some were not very relevant.	Student gathered information from a limited range of sources and displayed minimal effort in selecting quality resources	Student gathered information that lacked relevance, quality, depth and balance.
Analysis	Student carefully analyzed the information collected and drew appropriate and inventive conclusions supported by data.	Student conclusions shows good effort was made in analyzing the data collected	Student conclusions could be supported by stronger evidence. Level of analysis could have been deeper.	Student conclusions simply involved restating information. Conclusions were not supported by evidence.
Written Synthesis	Student developed appropriate structure for communicating data and conclusions, incorporating a variety of quality sources. Information is logically and creatively organized with smooth transitions. Little faculty assistance was required (mostly general editing).	Student logically organized the methods employed and results generated. Average faculty assistance was required.	Student could have put greater effort into organizing the thesis. Much faculty-generated assistance was required.	Student work was not logically or effectively structured and required extensive faculty-generated assistance.

This form is confidential and intended for long-term program evaluation.
Contents will not be directly shared with the student.
Please return to the MS Program Coordinator within one week of the defense date.

Thesis Defense Assessment Rubric

Student: _____ Reviewer: _____ (page 2)

* Point Value	4	3	2	1
Documentation	Student documented all sources. Sources were properly cited in both written thesis and presentation slides. Documentation is error-free.	Student documented sources are sufficient in general. Few errors noted.	Student needs to use greater care in documenting sources. Documentation was poor or absent.	Student(s) clearly plagiarized material.
Oral Synthesis	Student effectively and creatively used appropriate communication tools to convey their conclusions and demonstrated thorough, effective research techniques. Work displays creativity and originality.	Student effectively communicated the results of research to the audience.	Student needs to work on communicating more effectively.	Student showed little evidence of thoughtful research. Presentation does not effectively communicate research findings.
Critical Thinking	Student demonstrated critical thinking by asking appropriate questions, considering legitimacy of sources and evaluation of data	Student demonstrated critical thinking by asking appropriate questions and considering legitimacy of sources.	Student needed to ask more critical questions than normal in the process of working through the project.	Student did not apply critical thinking to the topic or the sources used in the research.
Comments:				

Point total: _____ out of 28

This form is confidential and intended for long-term program evaluation.
Contents will not be directly shared with the student.
Please return to the MS Program Coordinator within one week of the defense date.