POST MASTER'S CERTIFICATE IN
Biologics and Biosimilars Manufacturing

*The RAQA program offers two certificates related to biologics and biosimilars. The **Post Master's Certificate in Biologics and Biosimilars Manufacturing** provides a broad overview of the technical aspects of biologics manufacturing. However, if you are seeking a program with a greater emphasis on general regulatory aspects related to biologics and biosimilars we suggest you review the brochure for the **Post Master's Certificate in Biologics and Biosimilars: Regulatory Aspects**.*

BACKGROUND

Ever since the first biopharmaceutical product (recombinant human insulin) was approved in 1982, products derived through biotechnology have provided medical advances that include cell and gene therapies, therapeutic monoclonal antibodies, cancer vaccines, cytokines, antisense technology, interference RNA, and growth factors.

Temple's ***Post Master's Certificate in Biologics and Biosimilars Manufacturing*** focuses on CMC aspects in the development and manufacture of these products, preparing students for positions in the biopharmaceutical industry and sharpening the skills and knowledge of those already working in this field.

This certificate enables students to become fluent in the methods used in the discovery of biopharmaceutical products, including materials sourcing and testing requirements. Technologies and unique considerations associated with the manufacture of biopharmaceutical products are discussed.

Faculty are drawn from the FDA and the biopharmaceutical industry, assuring that the latest developments and practices are taught. They are industry veterans with years of expertise in their specialties, who share their considerable knowledge with students through classroom discussions and hands-on workshops.

The ***Post Master's Certificate in Biologics and Biosimilars Manufacturing*** enables students to sharpen their knowledge of this industry niche without committing to the entire master's degree.

Executive recruiters often seek candidates with demonstrated knowledge of the application of regulations to biologics and biosimilar manufacturing. The ***Certificate*** will provide students with credentials from Temple's well-respected Regulatory Affairs and Quality Assurance graduate program, giving them a solid grounding in the issues surrounding biopharmaceutical manufacturing.

The ***Post Master's Certificate*** is open to both MS applicants and also MS graduates, who can expand their career opportunities with this new credential.

LEARNING OBJECTIVES

Upon completion of the ***Post Master's Certificate*** students will understand the:

- CMC strategies for biologics and biosimilars at a deeper level;
- Phase appropriate regulatory compliance elements applicable to biologics and biosimilars manufacture;
- Major steps involved in the manufacture of biologics and biosimilars;
- Fundamentals of Quality by Design as relevant to biologics and biosimilars manufacture;
- Fundamentals of Statistical Process Control principles as relevant to biologics and biosimilars manufacture.

ACADEMIC REQUIREMENTS

1. It is strongly suggested that students have a Bachelor's degree in Biology, Chemistry, Engineering, Pharmacy, Physics or related fields, from an accredited institution of higher learning.
2. The ***Post Master's Certificate in Biologics and Biosimilars Manufacturing*** may be earned on its own or on the way to the MS in RA and QA. To earn the certificate, five courses must be completed within a four-year period with an overall B (3.0) average:

   Students must complete four required courses:

   - Biotechnology: Bioprocess Basics (RAQA 5471) – Students with prior educational or biologics manufacturing experience may substitute a course from the elective list below in lieu of this course.
   - Biologics/Biosimilars: A Regulatory Overview (RAQA 5515) – Students with prior educational or biologics regulatory experience may substitute a course from the elective list below in lieu of this course.
   - Global CMCs – Biopharmaceuticals and Other Biologics (RAQA 5577)
   - Pharmaceutical Biotechnology (8005)

   PLUS, students must complete one elective from the following:

   - Statistical Quality Control (RAQA 5451)
   - Validation of FUE (Facilities, Utilities, and Equipment (RAQA 5468)
   - Process Validation (RAQA 5474)
   - Advanced Good Manufacturing Practices – Defining "c" (RAQA 5479)
   - Production of Sterile Products (RAQA 5492)
   - Sterilization Processes (RAQA 5493)
   - Development of Sterile Products (RAQA 5501)
   - Microbiological Concepts in Pharmaceutical Manufacturing (RAQA 5512)
   - Cleaning Validation (RAQA 5516)
   - Vaccines: RA and QA Issues (RAQA 5572)
   - Statistical Design of Experiments (DOE) (RAQA 5627)
   - Process Monitoring (RAQA 5629)

2. All courses must be completed from Temple University's RAQA graduate program. No transfer credits from other institutions are accepted. If a student has completed an identical course at an accredited U.S. graduate school, the student may petition the RAQA program to waive that course and take another approved elective in its place. This request must be made in writing and approved before the student pursues the certificate.

3. Candidates must formally apply and follow the application procedures stated below (**Application Form**, photocopies of transcripts, and **Notice of Completion**).

4. Only one certificate program may be completed before students receive the M.S.

5. The certificate must be completed within four years. Students must apply for the certificate no more than one year after completing the course requirements.

6. Students interested in pursuing the RAQA MS degree may apply all credits earned in the ***Post Master's Certificate*** towards their graduate degree, provided they formally apply for admission to the MS program and are accepted by Temple University's Graduate School.

APPLICATON PROCESS

The ***Post Master's Certificate in Biologics and Biosimilars Manufacturing*** is part of Temple University's graduate program in Regulatory Affairs and Quality Assurance. It does not require the GRE. To earn the ***Certificate*** students must successfully complete all courses with an overall B average and formally apply for the certificate. To receive the certificate and letter of completion, the following must be submitted:

- **Application Form**
- Photocopies of all undergraduate and graduate transcripts from any schools previously attended, including Temple's RAQA program (copies of transcripts are acceptable; official transcripts are not required).
- **Notice of Completion**

These items must be mailed to:

Temple University School of Pharmacy
Regulatory Affairs and Quality Assurance Graduate Program
425 Commerce Drive, Suite 175
Fort Washington, PA 19034

TO RECEIVE THE CERTIFICATE

Certificates are not automatically conferred when students complete the required courses. Students must formally apply and must also forward the **Notice of Completion** either by mail or email to the RAQA Office (267.468.8565) indicating that they have finished the required courses. Photocopies of all undergraduate and graduate transcripts must be included.

The RAQA Office issues certificates in early February, June, and September. In order to receive your certificate in one of those months, you must submit your **Application Form**, transcripts, and **Notice of Completion** by these deadlines:

Jan 15 for certificates earned in the previous fall semester
May 15 for certificates earned in the previous spring semester
Aug 20 for certificates earned during the summer semesters

If you miss the deadline, you will need to wait until the next processing period.
It takes the RAQA Office approximately 6 weeks to process certificates. If you have not received your certificate by Feb 28, June 30, or Sept 30, please contact the RAQA Office.

DESCRIPTION OF COURSES

Required Courses

Students must complete the following required courses. Note: Students with prior educational biologics manufacturing or biologics regulatory experience may substitute from the elective list in lieu of 5471 and/or 5515.

5471. Biotechnology: Bioprocess Basics (3 credits)
Prerequisite: Undergraduate introductory Biochemistry and Chemistry courses.
This course emphasizes regulatory and control aspects of biologics manufacturing as well as Quality by Design (QbD) principles. It provides students with a basic understanding of the major steps involved in the manufacture of biologics/biopharmaceuticals, including preparation of media, fermentation, harvesting/recovery, purification and formulation. Included is a review of basic bioscience topics (e.g., microbiology, biochemistry, and molecular biology) with particular relevance to the study of bioprocessing techniques. *Not open to students who have taken RAQA 481.*

5515. Biologics/Biosimilars: A Regulatory Overview (3 credits)
Prerequisites: Drug Development (5459). Science background required.
Since the first biopharmaceutical product approval in 1982 (recombinant human insulin), the biotechnology derived product market has been rapidly growing with introduction of a number of promising advances in medicine such as therapeutic monoclonal antibodies, cancer vaccines, cytokines, antisense technology, interference RNA, and growth factors. As with traditional drugs (small molecules), the regulatory framework for approval of a biotechnology derived product (biologics) is complicated. In addition, there has been much debate about the introduction of biosimilars using an abbreviated approval process. An overall biologics-based process map beginning with pre-clinical through the post-marketing stage will be discussed. Topics such as therapeutic proteins/peptides, gene therapy, stem cells, vaccines, interference RNAs, PK-PD, world-wide regulatory filings, pre-clinical IND-enabling studies, BLA/CTD filing, biosimilars/follow-on-biologics, selected case studies, immunogenicity, comparability studies, manufacturing challenges, clinical trials, market exclusivity, and related regulatory guidelines will be discussed.

5577. Global CMCs - Biopharmaceuticals and Other Biologics (3 credits)
This course provides students with an introduction to the chemistry, manufacturing and controls (CMC) topics involved in the development and licensure of biologic products (biopharmaceuticals, vaccines) in the US, Europe and other highly regulated regions. Topics will be discussed from the perspective of Regulatory and QA requirements and expectations. Basic microbiology, cell biology and chemistry concepts will be reviewed with an emphasis on their practical application to product development and RA/QA. The class is designed to orient RA/QA professionals, managers and scientists responsible for biopharmaceutical CMC development and preparation of dossiers to the CMC content matter and technical issues that must be addressed in biologic product development and registration. Topics will include adventitious agents testing, cell and seed bank testing methods and requirements, drug substance production via cell culture, protein and virus purification methods, control and analysis of process impurities, analytical methods and potency testing for characterization and release, strategy for specification setting for release and stability, comparability studies for biologics.

8005. Pharmaceutical Biotechnology (3 credits)
This course introduces students to pharmaceutical biotechnology, biophysical and chemical aspects of biotech products, and their pharmaceutical formulations and clinical applications. Amino acids, proteins, peptides and nucleotides are of particular interest. The principles of pharmaceutical formulations and physicochemical evaluation of formulations will be discussed. Pharmacokinetics of biologics and current analytical methods used in pharmaceutical biotechnology are included. In addition, the course provides an introduction to biopharmaceuticals that encompass a variety of technologies ranging from products derived from natural sources, peptides, therapeutic proteins/monoclonal antibodies, oligonucleotide therapeutics (e.g. antisense, ribozymes, apatmers, siRNA), gene therapy and special issues in drug delivery. The course will begin with a review of the molecular, biochemical, pharmaceutical underpinnings that support each of the technologies and will move into a more detailed discussion of each therapeutic technology. Preclinical and clinical development, safety, efficacy and manufacturing issues will be discussed.
Not open to students who have taken Pharmaceutics 475.

Elective Courses

In addition, students must complete one of the following elective courses

5451. Statistical Quality Control (3 credits)
An introduction to statistical concepts, this course reviews control charts for variables, probability theory, control charts for attributes, and acceptance sampling systems. Class discussions include application to quality control of pharmaceutical manufacturing.
Not open to students who have taken RAQA 451.

5468. Validation of FUE (Facilities, Utilities and Equipment) (3 credits)
Prerequisite: Good Manufacturing Practices (5477) or appropriate industry experience in GMPs.
The production of FDA regulated products (pharmaceutical, medical device, food, etc.) is highly dependent on both the initial qualification of facilities, utilities, and equipment (FUE) along with the ongoing efforts to maintain the qualified/validated state by meeting current user and regulatory needs. This course focuses on the key validation elements specific to qualifying and validating facilities, utilities, and equipment. In practice, validation of these items is also a prerequisite for other validation efforts including process, cleaning and test method. The class will examine the key concepts of FUE qualification/validation as well as the life-cycle through retirement of the FUE.

5474. Process Validation (3 credits)
Prerequisites: BS in Pharmacy, Chemistry, Biology or Engineering and strong science background, including familiarity with chemistry, biology, and physics. Students should also have a basic understanding of pharmaceutical manufacturing processes.
Since the concept of "validation" originally appeared in GMP regulations, it has extended to every step in product manufacturing from building the plant to the methods used for testing and releasing its products. The course exposes students to all aspects of validation. FDA Guides and Guidelines, as well as the current emphasis on validation concerns by FDA (as identified in 483 and Warning Letter observations), will be incorporated. Students develop acceptable validation protocols and learn what constitutes an acceptable validation report.
Not open to students who have taken RAQA 484.

5479. Advanced Good Manufacturing Practices – Defining "c" (3 credits)
Prerequisite: successful completion of Good Manufacturing Practices (5477) or permission of the instructor.
This course brings students from the basic GMP concepts presented in Good Manufacturing Practices (5477) to a fuller understanding of the concepts of current good manufacturing practices. Discussions include how to evaluate FDA 483s and Warning Letters, the routine review of periodicals, including the Pink Sheet, Gold Sheet, and other GMP-oriented documents, and how to evaluate information provided by the FDA. Recalls are discussed.
Not open to students who have taken RAQA 479.

5492. Production of Sterile Products (3 credits)
This course reviews the theory and practice involved in the preparation of sterile, injectable products, covering formulation, manufacturing, facility requirements, validation and regulatory issues. Upon completion of the course, students will develop an understanding of the routes of administration of injectable drugs and the types of injections, current formulation methods, aseptic manufacturing processes, requirements for sterile manufacturing facilities, and validation, compliance and regulatory issues.
Not open to students who have taken RAQA 492.

5493. Sterilization Processes (3 credits)
This course surveys sterilization processes used in the pharmaceutical, medical device, in-vitro diagnostic, and biotech industries. Current methods of sterilization are discussed, including thermal, gaseous, radiation, filtration, and aseptic processing. Students learn basic aspects of sterilization science as well as design, review, and audit sterilization validations and processes according to industry practices.
Not open to students who have taken RAQA 493.

5501. Development of Sterile Products (3 credits)
A study of the theory and practice in the development of parenteral products; dosage form design, formulation, solubility/physical pharmacy, excipients, assays, stability, physiochemical properties of biomolecules, delivery systems for controlled/sustained release and manufacturing methods.
Not open to students who have taken Pharmaceutics 501.

5512. Microbiological Concepts in Pharmaceutical Manufacturing (3 credits)
This course addresses essential microbiology concepts of manufacturing and quality control that form the basis of Good Manufacturing Practices for both sterile and non-sterile pharmaceuticals. Emphasis is placed on a review of the following from a microbiological perspective: manufacturing technologies and techniques, building quality into processes, influence of raw material quality on finished product, the meaning of the qualification and validation studies conducted by drug firms, and key microbiological tests performed at in-process and finished product stages. The course stresses practical matters and includes case studies to prepare students for daily issues arising in industry.
Not open to students who have taken RAQA 512.

5516. Cleaning Validation (3 credits)
This course will cover the origins and historical development of cleaning validation and the current movement to Science-based, Risk-based and Statistics-based programs (ASTM Standard E3106). The course will review the chemistry and physics of cleaning and the development of cleaning processes, the calculation of cleaning limits, analytical method development and validation (with particular emphasis on Total Organic Carbon analysis and Visual Inspection) and how Risk Assessments are applied to the cleaning processes and their validation. The evolving regulatory landscape on cleaning validation starting from the FDA to the ICH to the EMA and other regulatory agencies will be discussed.

5572. Vaccines: RA and QA Issues (3 credits)
Suggested prerequisite: Drug Development (5459).
This course addresses the history, research and development, manufacture, marketing, and medical impact of vaccines. Various public policy, regulatory, ethical, and legal issues in this area are discussed as they pertain to the U.S. and, to some extent, international markets. Beginning with the eradication of smallpox, this course covers the

development of widely used vaccines against once common diseases (e.g., polio, mumps, varicella, etc.), to the development of vaccines against HIV, anthrax, and certain types of cancer.
Not open to students who have taken RAQA 572.

5627. Statistical Design of Experiments (DOE) (3 credits)
Prerequisite: familiarity with basic math. A statistical program (Minitab) will be used.
This course exposes students to the use of statistical methods for designing optimal processes used in industry, extensively using data sets and data charting. At the end of the course the student should be able to: create an experimental plan to optimize a process; create a screening study to limit the number of experiments; use surface methodology to set process specifications; and use specialized methodology for material analysis.

5629. Process Monitoring (3 credits)
Students are introduced to state-of-the art process monitoring and controls used in the pharmaceutical and biotechnology industries. Students will be shown how process control is an integral part of using Quality by Design to build quality into the product. A discussion of process flowcharting and improvement is followed by an introduction to the use of control charting and process capability analysis to assess the stability and capability of processes. These concepts, methods and tools are then integrated into a process performance and product quality monitoring and improvement system. The course concludes with an introduction to process improvement using lean and Six Sigma methods. The Minitab statistical software is used to enable the statistical calculations involved. Students deepen their understanding of the subject by completing a project that involves the collection and analysis of data measuring the performance of an operational process. At the end of the course students will be able to collect process monitoring data, analyze process data to assess process stability and capability, identify opportunities for improvement, conduct studies to solve problems and create process improvements, and use statistical software to analyze process data.

QUESTIONS AND ANSWERS

Where is Temple's RAQA program offered?
Temple University's RAQA program is based at Temple University Fort Washington in suburban Montgomery County, PA. For directions, visit our website:
http://www.temple.edu/pharmacy_QARA/map.htm
Over 60 courses are available online in real-time.

When can I start the program?
Courses in the RAQA program are offered during the fall, spring and summer semesters every year. You may start the certificate program at your convenience.

What course sequence is recommended?
The RAQA program offers over 80 different courses, which are rotated over a 2 to 3-year period. Courses are not necessarily offered every semester. We urge students to take courses when they are scheduled or to write to the RAQA Office if they wish to see a course scheduled in a particular semester.

How do I obtain a current class schedule?
See the RAQA website: **www.temple.edu/pharmacy_QARA**

How do I register for classes?
Please download the Registration and State Residency Forms from the RAQA homepage: **http://www.temple.edu/pharmacy_QARA/forms.htm**

Both are required the first time you register. Fax, mail, and electronic registrations do not guarantee your spot in a class, since sections fill quickly. We will contact you immediately if there are problems with your registration. The RAQA Office will send a confirmation when you are officially registered. You will also receive a notice via your TUmail account when your tuition statement is available, including the payment due date. Please make sure that you pay your bill by the due date, so you do not incur a late fee.

Do I need to submit GRE scores to complete the certificate?
No. GRE scores are not required for this certificate or for the MS in RAQA.

When should I indicate that I plan to pursue the certificate?
You do not need to submit an application form to start taking courses. In fact, you may simply complete the courses and then submit your application. If you intend to pursue the MS, however, it is important that you complete your application to the MS as soon as possible, so all of your coursework applies to your degree.

Can I complete both the *Post Master's Certificate* and the MS in RAQA?
Yes! You're welcome to complete both programs, but please be aware that the MS in RAQA has an entirely different application process. For additional information on the Master of Science in Regulatory Affairs and Quality Assurance, please request a Program Guide and an application form by calling 267.468.8560.

Can I transfer any credits from another graduate institution towards the *Post Master's Certificate*?
Sorry, but credits for courses taken at other institutions are not accepted. All courses must be from Temple University's RAQA graduate program. It is possible to have a requirement waived; however, another *approved* Temple University RAQA elective from the ***Post Master's Certificate*** will have to be taken in its place. To waive a course, please submit a letter to the Assistant Dean for approval.

Will the *Post Master's Certificate* automatically be awarded when I complete the courses?

No. You must formally apply to receive the certificate. This consists of submitting: 1) the **Application Form**, 2) copies of all undergraduate and graduate transcripts from any schools previously attended (photocopies are acceptable; original transcripts are not required), and 3) the **Notice of Completion** form.

When you have finished your courses, you must submit the **Notice of Completion** to the RAQA Office via fax (267.468.8565) by the stipulated deadlines (Jan 15, May 15, or Aug 20). Otherwise you will have to wait until the next time they are processed.

Is there a deadline for completing the courses?
You should complete the ***Post Master's Certificate*** within four years. If you need an extension, please email qara@temple.edu.

Can I complete two certificates in Temple's MS program?
Temple's RAQA program now offers certificates in multiple specialties. Students may complete only one certificate before pursuing the MS in RAQA; however, you are welcome to earn additional certificates after earning the MS in RAQA. Thus, if you prefer to earn the ***Drug Development Certificate*** before completing the MS, you may subsequently earn this ***Post Master's Certificate*** (or another post-master's certificate) after earning the MS. Courses may only be counted towards one certificate. Please refer to our homepage for more details: www.temple.edu/pharmacy_QARA/certificates.htm

For additional information:
Temple University School of Pharmacy
RAQA Graduate Program
425 Commerce Drive, Suite 175
Fort Washington, PA 19034
Voice: 267.468.8560
Fax: 267.468.8565
E-mail: QARA@temple.edu
www.temple.edu/pharmacy_QARA