Nanyang Technological University
Division of Chemistry and Biological Chemistry

Academic Year	2020/21	**Semester**	2
Course Coordinator	Ken Lee		
Course Code	CM5031		
Course Title	Analytical & Manufacturing Techniques in Pharmaceutical Industry		
Pre-requisites	CM2031 Organic & Bioorganic Chemistry or by permission		
Mutually exclusive	NA		
No of AUs	3 AU		
Contact Hours	Lectures: 26 hours (2 hours per week) Laboratory: 27 hours (3 hours lab sessions per week)		
Proposal Date	10 November 2020		

Course Aims

Pharmaceutical manufacturing is a significant and critical component of Singapore's manufacturing industry. As such, any chemistry graduate aspiring to enter this industry as a career, must have a good knowledge and understanding of all aspects of this sector. The lectures are intended to provide you with an overall understanding of the process of drug discovery, development and in-depth exposure to the manufacturing aspect. Analytical chemistry is a crucial segment of quality control in drug manufacturing and the lab component is designed to supplement the lectures by providing you with hands-on training on advanced analytical and characterization skills relevant to pharma-needs. This course aims to equip you with an awareness of the overall Drug Discovery and Development process. Additionally, it will give you an in depth understanding of the Development aspect, which includes Chemical Development, Manufacturing and Formulation, Chemistry, Manufacturing & Controls (CMC), traditional batch method and emerging technologies such as flow chemistry, and an understanding of the critical role of analytical methods across these activities (e.g. PAC/PAT).

Intended Learning Outcomes (ILO)

By the end of this course, you (as a student) would be able to:

1. Describe process Chemistry; explain the transition from Pre-development synthetic routes to Development phase
2. Describe the various manufacturing techniques; involved in the production of Active Pharmaceutical Ingredient (API) on Kilo/Ton scale
3. Describe formulation; list the various techniques involved in the conversion of API to Drug Product (e.g. powder to tablet)
4. Describe flow Chemistry technique; compare with traditional batch method
5. Explore and evaluate continuous manufacturing
6. Explore and evaluate additive manufacturing ('3D printing') of tablets
7. Carry out analytical experiments using HPLC and GC; especially in the context of process analytical chemistry/technology (PAC/PAT); collect, interpret and report the data.

Course Content

Drug Discovery and Development Process

Target Identification and Validation; Hit and Lead Identification; Medicinal Chemistry/Optimization; Translation to Clinical Development; Development; Approval and Marketing of drug.

Chemical Development, Manufacturing and Formulation

Conversion of preclinical synthetic route to development scale; process chemistry; production of API on kilo and ton scale; CMC and the regulated process of manufacture; GMP; formulation of API to drug product; batch method of synthesis; flow chemistry; continuous manufacturing; additive manufacturing.

Analytical methods in pharmaceutical manufacturing activities
Application of HPLC and GC; Process Analytical Testing (PAT); Process Analytical Chemistry (PAC)

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team / Individual	Assessment Rubrics
1. Final Examination	All	Competence, written communication	50%	Individual	
2. Lab	7	Competence	25%	Individual	Appendix 1
3. CA 1 (test)	1, 2, 3	Competence	10%	Individual	
4. CA 2 (test)	4, 5, 6, 7	Competence	15%	Individual	
Total			100%		

Formative feedback

Feedback given after each midterm on the common mistakes and level of difficulty of the problems.

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
Faculty delivered (Lecture)	The students learn fundamentals of Pharmaceutical Manufacturing, and the approaches currently being employed by the industry
Invited industry expert (Lecture)	The students will hear directly from industry experts, with real world examples of pharmaceutical drug manufacturing
Lab sessions	Hands-on training with GC/HPLC machines, done in groups

Reading and References

1) Process Chemistry in the Pharmaceutical Industry. (Ed., Kumar. G. Gadamasetti, CRC Press, ISBN 9780824719814).
2) Process Understanding: For Scale-Up and Manufacture of Active Ingredients (Ed., Ian Houson, Wiley-VCH, ISBN: 978-3-527-32584-9).
3) Pharmaceutical Preformulation and Formulation: A Practical Guide from Candidate Drug Selection to Commercial Dosage Form (Ed., M. Gibson, CRC Press, 9781420073171.
4) Relevant scientific literature

Course Policies and Student Responsibilities

Absence Due to Medical or Other Reasons

If you are sick and unable to attend your class (particularly the mid-terms), you have to:

1. Send an email to the instructor regarding the absence and request for a replacement class.
2. Submit the original Medical Certificate* to administrator.
3. Attend the assigned replacement class (*subject to availability*).

* The medical certificate mentioned above should be issued in Singapore by a medical practitioner registered with the Singapore Medical Association.

Academic Integrity

Good academic work depends on honesty and ethical behavior. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honor Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
Ken Lee	SPMS-CBC 04-02	+65 65132178	ken.lee@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Introduction to Drug Discovery and Development Process	1, 2, 3	
2	CMC overview	1, 2, 3	
3	Process development 1	1, 2, 3	
4	Process development 1	1, 2, 3	
5	API manufacture	1, 2, 3	
6	Drug product formulation	1, 2, 3	CA1
7	Case study 1	1, 2, 3, 4, 5, 6, 7	
8	Chemical engineering considerations	1, 2, 3	
9	In-process controls and analysis	7	
10	Continuous processing	4, 5, 6	
11	Additive manufacturing	4, 5, 6	
12	Synthetic biochemistry in manufacturing	4, 5, 6	CA2
13	Case study 2	1, 2, 3, 4, 5, 6, 7	
4-12	Weekly 3 hours of lab	7	Weekly lab reports

MT* Mid-term - to be conducted off regular curriculum time (in the evenings or Saturdays)
Pre/Post-lecture online assignments; Post Lecture tutorial lessons

PR – short progress report of project synopsis to tutors

Appendix 1: Assessment Criteria (for Lab)

Standards	Criteria
A+ to A-	**Excellent work* which is clearly outstanding and is characterized by**: An extremely impressive and consistent performance in the analytical experiments and pre-lab quiz as evidenced by highly accurate data and consistent and correct pre-lab quiz completion (LO 7, weighting 25%). Clearly contributed as a team member.
B+ to B-	**Very good work* that is characterized by:** b) Very good and consistent performance in the analytical experiments as evidenced by highly accurate data and consistent and mostly correct completion of pre-lab quiz (LO 7, weighting 25%). Contributed fairly as a team member.
C+ to C	**Good work* that is characterized by:** Fair and consistent performance in the analytical experiments as evidenced by accurate data and satisfactory completion of pre-lab quiz (LO 7, weighting 25%). Some contribution as a team member.
D+ to D	**Acceptable work* that is characterized by:** Acceptable performance in the analytical experiments as evidenced by data of reasonable accuracy and satisfactory involvement in pre-lab quiz (LO 7, weighting 25%). Contributed in insignificant ways to the team.
F	**Work* that do not meet the minimum criteria and is characterized by:** Poor performance in the analytical experiments as evidenced by data of unacceptably low accuracy and poor performance in pre-lab quiz (LO 7, weighting 25%). Absent or no observable participation in team work.

** The term work refers to lab reports, presentations, team discussion and other assignments the students are required to undertake as part of the evaluation. Assessment is purely individual.*

Appendix 1: CBC Programme Learning Outcomes

1. Competence

a. Be well-versed in the foundational and advanced concepts of chemical science
b. Evaluate chemistry-related information critically and independently
c. Use complex reasoning to solve emergent chemical problems

2. Creativity

a. Synthesize and integrate multiple ideas across the curriculum
b. Propose innovative solutions to emergent chemistry-related problems based on their training in chemistry

3. Communication

a. Demonstrate clarity of thought, independent thinking, and sound scientific analysis and reasoning through written and oral reports to audiences with varying technical backgrounds
b. Effectively engage other professional chemists in collaborative endeavours

4. Character

a. Act in responsible ways
b. Uphold the high ethical standards that the society expects of professional chemists

5. Civic-mindedness

a. Be aware of the impact of chemistry on society
b. Apply chemistry to benefit mankind
c. Uphold the best chemical safety practices