

|                           |                                                                           |                 |              |
|---------------------------|---------------------------------------------------------------------------|-----------------|--------------|
| <b>Academic Year</b>      | 2020/2021                                                                 | <b>Semester</b> | Special Term |
| <b>Course Coordinator</b> | So Cheuk-Wai                                                              |                 |              |
| <b>Course Code</b>        | CM5071                                                                    |                 |              |
| <b>Course Title</b>       | Undergraduate Research Experience in Chemistry and Biological Chemistry I |                 |              |
| <b>Pre-requisites</b>     | Approval by the Division                                                  |                 |              |
| <b>No of AUs</b>          | 4 AU                                                                      |                 |              |
| <b>Contact Hours</b>      | 400 laboratory hours (12-week undergraduate research project)             |                 |              |
| <b>Proposal Date</b>      | 16 Mar 2020                                                               |                 |              |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <b>Course Aims</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |  |
| <p>The purpose of this undergraduate research course is to enable the application of basic knowledge and skills you have learnt in the university in an authentic research environment. This is such that you can gain relevant exposures and develop basic research experiences and skills, which allow you to develop research competencies for the future of work and graduate studies. This course provides you with an opportunity to carry out research with one or more faculty members in the Division of Chemistry and Biological Chemistry.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |
| <b>Intended Learning Outcomes (ILO)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  |
| <b>I. Cognitive</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| <ol style="list-style-type: none"> <li>1. Apply basic knowledge and skills relevantly and appropriately in the chemistry research laboratory. [Apply basic chemistry knowledge, logical reasoning, basic chemical laboratory and/or computational skills to analyse and solve problems in a research project]</li> <li>2. Identify your own competency gaps at the chemistry research laboratory.</li> <li>3. Evaluate and develop personal learning and development pathways towards bridging competency gaps identified in point (2) above. [Identify technical skills needed to solve problems in a research project]</li> <li>4. Develop and apply strategies to solve problems effectively (involves critical thinking and creativity, generating questions, resourcing, application and reiteration). [To formulate research question; methodically develop approaches to tackle problems using scientific approach; collect and analyse data to make rigorous and objective deductions.]</li> <li>5. Evaluate resources and develop insights to make informed judgements and recommendations. [Exhibit awareness of relevant knowledge through literature review and critically evaluate sources of scientific/non-scientific information.]</li> </ol> |  |
| <b>II. Context</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |  |
| <ol style="list-style-type: none"> <li>6. Discuss and Appraise significance, impact results and future plan of the research project</li> <li>7. Reflect on the culture at the chemistry research laboratory.</li> <li>8. Reflect on personal and professional development needs within the chemistry research laboratory.</li> <li>9. Apply time and task management strategies effectively. [Spend adequate time on the project to ensure rigour and quality]</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |
| <b>III. Relationship</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |  |
| <ol style="list-style-type: none"> <li>10. Apply effective written and oral communication skills in professional settings when communicating and connecting with research supervisor and colleagues. [Communicate (in writing and speaking) scientific and non-scientific ideas effectively to professional scientists]</li> <li>11. Assimilate into the work environment (people, team, hierarchy) and function effectively. [Communicate effectively with team members when working in a group and contribute as a valued team member when working in a group]</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  |

#### IV. Affective/Moral

12. Tolerate ambiguity and handle anxiety.
13. Contribute proactively to the chemistry research laboratory.
14. Demonstrate responsibility, integrity and professionalism in the fulfilment of all research requirements. [Readily pick up new skills, particularly technology related ones, to tackle new problems.]
15. Demonstrate the persistence to learn, overcome and improve.

#### V. Technical

16. Use tools that enable and facilitate effective project/work/assignment undertaken at the chemistry research laboratory.

#### Course Content

In this undergraduate programme, you (as a student) will experience supervised research work in a selected field of study. You will be supervised by the faculty from the Division of Chemistry and Biological Chemistry to achieve the intended learning outcomes listed above. The specific content is dependent on the selection field of study.

#### Assessment (includes both continuous and summative assessment)

| Component            | Course LO Tested | Related Programme LO or Graduate Attributes                        | Weighting | Team/ Individual | Assessment rubrics                                          |
|----------------------|------------------|--------------------------------------------------------------------|-----------|------------------|-------------------------------------------------------------|
| 1. Performance       | 1-16             | Competency, Creativity, Communication, Character, Civic-mindedness | 40        | Individual       | See Annex 1 for rubric. Assessed by CBC Faculty Supervisor. |
| 2. Written Report    | 1-5, 10-11, 16   | Competency, Creativity, Communication, Character                   | 30        | Individual       | See Annex 2 for rubric. Assessed by CBC Faculty Supervisor. |
| 3. Oral Presentation | 1-5, 10-11, 16   | Competency, Creativity, Communication, Character                   | 30        | Individual       | See Annex 3 for rubric. Assessed by CBC Faculty Supervisor. |
| Total                |                  |                                                                    | 100%      |                  |                                                             |

This is a Pass/Fail graded course with the final outcome determined by your Faculty Supervisor.

The assessments will be based on the above intended learning outcomes (ILOs) and you should familiarise yourself with them as they will be your focus throughout the undergraduate research programme.

Your Faculty Supervisor will assess your performance at the chemistry research laboratory, written report and oral presentation through "Assessment of Work in the Chemistry Research Laboratory", "Assessment Rubrics for Written Report", and "Assessment Rubrics for Oral Presentation" respectively. He/She will complete the evaluation at the end of your programme.

**Formative feedback**

Continuous feedback on progress and performance can be expected from your supervisor.

**Learning and Teaching approach**

The undergraduate research programme is an experiential research programme done in a professional setting. You will be placed in a chemistry research laboratory and will undertake work assignments and research projects, where you learn to be responsible, independent, self-disciplined and self-motivated. You are expected to become better at managing your time, resources and emotions in this supervised research work. You would also acquire critical and logical thinking skills, and creative problem solving skills. You would gain confidence in your work and themselves, and develop fine oral and written communication skills. The CBC Faculty Supervisor will be the key person working with and interacting with you on a day-to-day basis.

**Reading and References**

Reading materials are dependent on the selected field of study and specific to each project. Faculty Supervisor will recommend reading materials, and students will conduct a comprehensive literature review as well.

**Course Policies and Student Responsibilities****(1) General**

Students are expected to complete all assigned readings and research activities, attend all research group meetings punctually and take all scheduled laboratory duties by due dates. Students are expected to participate in all research discussions and activities.

**(2) Absenteeism**

Absence from daily research activities without a valid reason will affect your overall course grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies. You must inform your Faculty Supervisor via email prior to any absence.

**Academic Integrity**

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour 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**

Your Supervisor for the undergraduate programme will be allocated to you after the placement process is completed. The First Undergraduate Research Opportunity in Chemistry and Biological Chemistry programme is managed and administered by your school's course coordinator.

| Course Coordinator | Office Location | Phone     | Email           |
|--------------------|-----------------|-----------|-----------------|
| So Cheuk-Wai       | SPMS-CBC 06-17  | 6513 2730 | CWSo@ntu.edu.sg |

**Planned Weekly Schedule**

The weekly schedule will be discussed and agreed on between students and their Faculty Supervisors.

### Annex 1: Assessment Rubrics for Assessment of Work in the Chemistry Research Laboratory

Criteria for the assessment of student performance in the chemistry research laboratory:

| ILOs | Focus                                                                   | Criteria                                                                                                                                                                                                                                   |
|------|-------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | Knowledge and Skills<br>[Scientific approach to problem solving]        | Able to apply knowledge and skills (whether prior or newly learned) appropriately in the workplace and/or projects/tasks.<br><br>[Able to put together analytical, laboratory and/or computational skills to solve quantitative problems.] |
| 4    | Problem-solving                                                         | Able to solve problems systematically and effectively.                                                                                                                                                                                     |
| 5    | Resourcefulness<br>[Awareness of relevant knowledge, skills needed]     | Able to source for relevant information to make informed judgement, decisions and/or recommendations.<br><br>[Able to handle information critically and propose systematic approaches to handling problems.]                               |
| 9    | Time and Task Management                                                | Able to plan, organise, manage and complete assignments effectively and in a timely manner.                                                                                                                                                |
| 10   | Written and Oral Communication                                          | Able to communicate effectively and appropriately in writing and verbally                                                                                                                                                                  |
| 11   | Team Work                                                               | Able to function effectively with other colleagues/stakeholders in the work environment.                                                                                                                                                   |
| 12   | Adaptability                                                            | Able to function effectively under ambiguity and/or change.                                                                                                                                                                                |
| 13   | Initiative                                                              | Able to remain consistently pro-active towards contributing to the work and/or organisation.                                                                                                                                               |
| 14   | Responsibility                                                          | Consistently demonstrates commitment, responsibility, integrity, professionalism and ethical behaviour at the workplace.                                                                                                                   |
| 15   | Persistence to Learn and Improve<br>[Particularly technological tools.] | Consistently demonstrates persistence and grit to overcome challenges, to learn and improve continuously at the workplace.                                                                                                                 |
| 16   | Fluency with Tools                                                      | Able to use tools, whether software or hardware tools, (and learn new ones where necessary) proficiently to accomplish tasks and assignments.                                                                                              |

| <b>Standards</b> | <b>Levels of Achievement of the Criteria</b>                                                                  | <b>Grade</b> |
|------------------|---------------------------------------------------------------------------------------------------------------|--------------|
| <b>A+</b>        | <b>OUTSTANDING</b> levels of these skills with ability extending significantly beyond the undergraduate level | <b>PASS</b>  |
| <b>A</b>         | <b>EXCELLENT</b> levels of these skills with some extension beyond the undergraduate level                    | <b>PASS</b>  |
| <b>A-</b>        | <b>GOOD</b> Levels of these skills, reliable and efficient                                                    | <b>PASS</b>  |
| <b>B+</b>        | <b>SOUND</b> levels of these skills, generally satisfactory skills                                            | <b>PASS</b>  |
| <b>B</b>         | <b>BASIC</b> level of these skills                                                                            | <b>PASS</b>  |
| <b>B-</b>        | <b>LIMITED</b> level of these skills                                                                          | <b>PASS</b>  |
| <b>C+ to C</b>   | <b>POOR</b> level of these skills                                                                             | <b>PASS</b>  |
| <b>D+ to D</b>   | <b>MINIMAL</b> level of these skills                                                                          | <b>PASS</b>  |
| <b>F</b>         | <b>ABSENT</b> , did not demonstrate these skills                                                              | <b>FAIL</b>  |

## Annex 2: Assessment Rubrics for Written Report

Your written report in a professional setting will be assessed at the end of this undergraduate research programme by the CBC Faculty Supervisor using the following criteria:

| Category                        | Scoring Criteria                                                                                                                                  |
|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Organization</b>             | Content is organized and presented in a clear, coherent and logical sequence.                                                                     |
|                                 | Correct use of referencing throughout, formatted in the correct scientific specification.                                                         |
|                                 | Proper literature review was done and references were properly cited.                                                                             |
|                                 | Appropriate use of figures, tables and graphs to communicate data and information.                                                                |
| <b>Content</b>                  | Clear description of project's objectives, motivations, interpretation and explanation of research approach, process and findings.                |
|                                 | Technical terms are well-defined in language appropriate for the subject area.                                                                    |
|                                 | Report contains accurate information.                                                                                                             |
|                                 | Material included is relevant to the overall message/purpose.                                                                                     |
|                                 | Appropriate amount of material is prepared, and points made reflect well their relative importance.                                               |
|                                 | Shows clear understanding of key concepts/theories, and interpretation of wider context issues.                                                   |
|                                 | Strong links made between problem statement, claims made, tools used and results.                                                                 |
|                                 | Discussion and conclusions tie well with the problem statement and results obtained.                                                              |
| <b>Difficulty / Originality</b> | Is this project a new initiative or is it approaching a previous or ongoing project from a brand new perspective?                                 |
|                                 | Does the project involve very sophisticated theory or does it require heavy and challenging code development?                                     |
|                                 | Has the student developed original models or original results, novel and creative application of existing techniques/discovery of new principles? |
|                                 | Clarity and distinct originality of thought, with clear link to major topics from research materials, as well as important linked topics.         |
| <b>Effort</b>                   | The project involves substantial work and intellectual demand befitting of a university final year project.                                       |

| <b>Standards</b> | <b>Levels of Achievement of the Criteria</b>                                                                  | <b>Grade</b> |
|------------------|---------------------------------------------------------------------------------------------------------------|--------------|
| <b>A+</b>        | <b>OUTSTANDING</b> levels of these skills with ability extending significantly beyond the undergraduate level | <b>PASS</b>  |
| <b>A</b>         | <b>EXCELLENT</b> levels of these skills with some extension beyond the undergraduate level                    | <b>PASS</b>  |
| <b>A-</b>        | <b>GOOD</b> Levels of these skills, reliable and efficient                                                    | <b>PASS</b>  |
| <b>B+</b>        | <b>SOUND</b> levels of these skills, generally satisfactory skills                                            | <b>PASS</b>  |
| <b>B</b>         | <b>BASIC</b> level of these skills                                                                            | <b>PASS</b>  |
| <b>B-</b>        | <b>LIMITED</b> level of these skills                                                                          | <b>PASS</b>  |
| <b>C+ to C</b>   | <b>POOR</b> level of these skills                                                                             | <b>PASS</b>  |
| <b>D+ to D</b>   | <b>MINIMAL</b> level of these skills                                                                          | <b>PASS</b>  |
| <b>F</b>         | <b>ABSENT</b> , did not demonstrate these skills                                                              | <b>FAIL</b>  |

### Annex 3: Assessment Rubrics for Oral Presentation

Your **slideshow** presentation in a professional setting will be assessed at the end of this undergraduate research programme by the CBC Faculty Supervisor using the following criteria:

| Category     | Scoring Criteria                                                                                                              |
|--------------|-------------------------------------------------------------------------------------------------------------------------------|
| Organization | The presentation is appropriate for the topic and audience.                                                                   |
|              | Information is presented in a logical sequence.                                                                               |
|              | Presentation appropriately cites references used.                                                                             |
| Content      | Introduction is captures attention; the problem is well defined and establishes a framework for the rest of the presentation. |
|              | Technical terms are well-defined in language appropriate for the target audience.                                             |
|              | Presentation contains accurate information.                                                                                   |
|              | Material included is relevant to the overall message/purpose.                                                                 |
|              | Appropriate amount of material is prepared and points made reflect well their relative importance.                            |
|              | There is an obvious conclusion summarizing the presentation.                                                                  |
| Presentation | Speaker maintains good eye contact with the audience and is appropriately animated (e.g., gestures, moving around, etc.).     |
|              | Speaker uses a clear and audible voice.                                                                                       |
|              | Delivery is poised, controlled, and smooth.                                                                                   |
|              | Good language skills and pronunciation.                                                                                       |
|              | Visual aids are well prepared, informative, effective, and not distracting.                                                   |
|              | Length of presentation is within the assigned time limits.                                                                    |
|              | Content is presented in a clear and concise way.                                                                              |
| Q & A        | Able to answer questions in a way that reflects a good understanding of the project.                                          |



| <b>Standards</b> | <b>Levels of Achievement of the Criteria</b>                                                                  | <b>Grade</b> |
|------------------|---------------------------------------------------------------------------------------------------------------|--------------|
| <b>A+</b>        | <b>OUTSTANDING</b> levels of these skills with ability extending significantly beyond the undergraduate level | <b>PASS</b>  |
| <b>A</b>         | <b>EXCELLENT</b> levels of these skills with some extension beyond the undergraduate level                    | <b>PASS</b>  |
| <b>A-</b>        | <b>GOOD</b> Levels of these skills, reliable and efficient                                                    | <b>PASS</b>  |
| <b>B+</b>        | <b>SOUND</b> levels of these skills, generally satisfactory skills                                            | <b>PASS</b>  |
| <b>B</b>         | <b>BASIC</b> level of these skills                                                                            | <b>PASS</b>  |
| <b>B-</b>        | <b>LIMITED</b> level of these skills                                                                          | <b>PASS</b>  |
| <b>C+ to C</b>   | <b>POOR</b> level of these skills                                                                             | <b>PASS</b>  |
| <b>D+ to D</b>   | <b>MINIMAL</b> level of these skills                                                                          | <b>PASS</b>  |
| <b>F</b>         | <b>ABSENT</b> , did not demonstrate these skills                                                              | <b>FAIL</b>  |

## **CBC Programme Learning Outcome**

The Division of Chemistry and Biological Chemistry (CBC) offers an undergraduate degree major in Chemistry that satisfies the American Chemical Society (ACS) curricular guidelines and equips students with knowledge relevant to the industry. Graduates of the Division of Chemistry and Biological Chemistry should have the following key attributes:

### **1. Competence**

Graduates should be well-versed in the foundational and advanced concepts of chemical science, be able to evaluate chemistry-related information critically and independently, and be able to use complex reasoning to solve emergent chemical problems.

### **2. Creativity**

Graduates should be able to synthesize and integrate multiple ideas across the curriculum, and propose innovative solutions to emergent chemistry-related problems based on their training in chemistry.

### **3. Communication**

Graduates should be able to demonstrate clarity of thought, independent thinking, and sound scientific analysis and reasoning through written and oral reports to audiences with varying technical backgrounds. They should also be able to effectively engage other professional chemists in collaborative endeavours.

### **4. Character**

Graduates should be able to act in responsible ways and uphold the high ethical standards that the society expects of professional chemists.

### **5. Civic-mindedness**

Graduates should be aware of the impact of chemistry on society, and how chemistry can be applied to benefit mankind. They should also be aware of and uphold the best chemical safety practices.