课程大纲
COURSE SYLLABUS

1.	课程代码/名称 **Course Code/Title**	**生物电子显微图像的基本概念和高级处理** **Biological electron microscopy images: basic concepts and advanced processing**
2.	课程性质 **Compulsory/Elective**	选修 Elective
3.	开课单位 **Offering Dept.**	生命科学学院化学生物系 School of Life Sciences, Department of Chemical Biology
4.	课程学分/学时 **Course Credit/Hours**	2/32
5.	授课语言 **Teaching Language**	中英文 (Chinese and English)
6.	授课教师 **Instructor(s)**	廖茂富 (Maofu LIAO)
7.	开课学期 **Semester**	秋季 (Fall)
8.	是否面向本科生开放 **Open to undergraduates or not**	否 (No)
9.	先修要求 **Pre-requisites**	（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.） 无 (No)

10.	教学目标 **Course Objectives**

（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

生物电子显微学是从生物样品的电镜图像来获取结构信息的交叉领域，此科研方向近年来迅猛发展，来源于生物、计算、物理和材料等学科的共同推动。本课程的目标是为各相关专业的学生介绍生物电子显微图像的基本概念和处理方法。通过理论介绍和软件展示，使学生全面理解电子显微图像处理的基本概念和关键操作，学会根据样品的不同特点来优化图像处理流程，解决生物结构解析工作中的具体问题。

Biological electron microscopy is an interdisciplinary field in which researchers obtain structural information from electron microscopy images of biological samples. This research direction has developed rapidly in recent years, driven by the joint efforts of disciplines such as biology, computation, physics, and material sciences. The goal of this course is to introduce the basic concepts and processing methods of biological electron microscopy images to students in various related majors. Through theoretical introduction and software demonstration, students will comprehensively understand the fundamental concepts and key operations of electron microscopy image processing, learn to optimize the processing workflow according to different characteristics of the samples, and solve specific problems in biological structure determination.

11.	教学方法 **Teaching Methods**

（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

课堂理论介绍和软件展示。
Theoretical introduction and software demonstration in classroom.

12.	教学内容

Course Contents （如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）	

Section 1	生物电子显微学介绍
	Introduction of electron microscopy in biology (2hrs)
	1. 研究生物问题的主要电镜方法
	  Major electron microscopy methods to study biology (1hr)
	2. 冷冻电镜概述和"分辨率革命"
	  Overview of cryo-EM and "resolution revolution" (1hr)

Section 2	电镜图像的基本概念和操作
	Basic concepts and operations of EM images (2hrs)
	1. 透射电镜图像的形成
	  Image formation in transmission EM (1hr)
	2. 电镜图像的基本性质和操作
	  Key properties and operations of EM images (1hr)

Section 3	电镜图像处理中的傅里叶变换
	Fourier transform in EM image processing (2hrs)
	1. 傅里叶变换进行图像处理的基本概念
	  Basic concepts of Fourier transform in image processing (1hr)
	2. 傅里叶变换在电子显微学中的应用
	  Application of Fourier transform in electron microscopy (1hr)

Section 4	二维对齐算法和颗粒挑选
	2D alignment algorithms and particle picking (4hrs)
	1. 二维图像对齐的基本概念
	  Basic concepts of 2D image alignment (1hr)
	2. 使用不同的变换对齐二维图像
	  Usage of different transforms to align 2D images (2 hrs)
	3. 颗粒挑选策略
	  Strategies of particle picking (1hr)

Section 5	二维分类算法
	2D classification algorithms (2hrs)
	1. 电镜图像的主成分分析
	  Principle component analysis for EM images (1hr)
	2. 基于随机种子的二维分类
	  2D classification based on random seeds (1hr)

Section 6	三维重构和生成初始三维密度图
	3D reconstruction and generation of initial 3D map (4 hrs)
	1. 综述三维投影和反投影的迭代
	  Overview of iterative 3D projection and back-projection (1hr)
	2. 三维投影角度的惯例原则
	  Conventions of 3D projection angles (1hr)
	3. 生成初始三维密度图的不同策略
	  Different strategies for generating initial 3D map (2hrs)

Section 7	三维精修的基本方法 **Basic methods of 3D refinement** (2hrs) 1. 颗粒精修的 5 个参数 The five parameters for particle alignment (1hr)

		2. 使用最佳匹配策略进行三维精修 3D refinement using the best-match strategy (1hr)
	Section 8	电镜相机和漂移校正 **EM cameras and motion correction** (2hrs) 1. 不同电子探测器的介绍 Introduction of different electron detectors (1 hr) 2. 直接电子探测器、影片和漂移校正 Direct electron detectors, movies, and motion correction (1 hr)
	Section 9	欠焦值计算 **Defocus calculation** (2 hrs) 1. 介绍对比度传递函数和欠焦 Introduction of contrast transfer function and defocus (1 hr) 2. 计算欠焦值的不同算法 Different algorithms to calculate defocus (1hr)
	Section 10	基于概率的三维分类和精修 **Probability-based 3D classification and refinement** (4 hrs) 1. 三维分类介绍 Introduction of 3D classification (1hr) 2. 有监督和无监督的三维分类 Supervised and unsupervised 3D classification (1 hr) 3. 基于概率的三维分类软件 Probability-based 3D classification programs (2hr)
	Section 11	掩码和集中三维精修 **Mask and focused 3D refinement** (4 hrs) 1. 三维掩码介绍 Introduction of 3D mask (1 hr) 2. 使用三维掩码进行集中的三维分类 Application of 3D mask in focused 3D classification (1 hr) 3. 信号减法的集中三维分类 Focused 3D classification with signal subtraction (2 hrs)
	Section 12	分辨率和电镜密度图的质量 **Resolution and EM map quality** (2 hrs) 1. 全局和本地分辨率的计算 Calculation of global and local resolution (1 hr) 2. 报告分辨率和电镜密度图质量的评估方法 Evaluation of reported resolution and EM map quality (1 hr)
13.	课程考核 **Course Assessment**	

（①考核形式 Form of examination；②.分数构成 grading policy；③如面向本科生开放，请注明区分内容。If the course is open to undergraduates, please indicate the difference.）

上课出席 20%，平时作业 40%，期末作业 40%
Attendance 20%, homework 40%, final assignment 40%.

| **14.** | 教材及其它参考资料
Textbook and Supplementary Readings | |

一系列电镜图像处理的的研究文章和处理软件的说明书等。
A series of research papers on electron microscopy image processing and the manuals of processing software.