GLOBAL OPEN COURSES

全球课堂

2024 SPRING

北京大学教务部　北京大学国际合作部　北京大学教师教学发展中心

Office of Educational Administration
Office of International Relations
Center for Excellent Teaching and Learning
Peking University

Website: *www.oir.pku.edu.cn/goc*

CATALOG

目录

本手册配图来源：崔喆　王萌

序言

现代大学的发展史是一部不断变革的历史，时代在不断发展，我们的教育和教学方式也需要随之改变。现代技术的快速发展，改变了人们的生活方式、学习方式和工作方式，人们已经有了更多途径获取所需要的信息。加强全球合作、强化大学之间的协同创新、建设国际合作新模式是高等教育主动作为、应对挑战的科学道路。当今时代，随着新一轮科技革命和产业变革的到来，大学又一次面临着巨变，突如其来的疫情加速了这一进程。在后疫情时代，在线教育将深刻改变大学的组织形式，大学的边界将发生新的变迁和拓展，教学科研和管理将迭代升级，应充分利用网络实现线上线下教育的深度融合，在“云端”重塑教育形态。

2024 年春季，北京大学继续推出“全球课堂”项目—将北大（线下）课程同步分享给海外院校学生，使中外学生“云端”相聚，共同学习。

北京大学愿与更多高校联手，着力打造更具包容性的课程平台，为培养年轻一代做出不懈努力。

PREFACE

The history of the development of modern universities is a history of constant change. The times are constantly evolving, and our education and teaching methods need to be updated accordingly. The rapid development of modern technology has changed people’s way of life, study and work, and people have multiple ways to obtain the information they need. Strengthening global cooperation, strengthening collaborative innovation between universities, and building a new model of international cooperation are the scientific roads for higher education to take the initiative to respond to contemporary challenges. In today’s era, with the advent of a new cycle of technological revolution and industrial transformation, universities are once again facing great changes, and the sudden epidemic has accelerated this process. In the post-epidemic era, online education will profoundly change the organizational form of universities; the boundaries of universities will undergo new changes and expansion; teaching, research and management will be iteratively upgraded; and the network must be fully utilized to achieve deep integration of online and offline education, and to reshape the form of education in the “cloud.”

In the spring of 2024, Peking University will continue the “Global Open Courses” program, under which selected Peking University offline courses will be offered to overseas college students to attend synchronously with their peers at PKU, so that Chinese and foreign students can “gather in the cloud” and learn together.

Peking University would like to increase its collaboration with universities worldwide to build a more inclusive curriculum platform as part of its constant effort to seek better ways to cultivate the younger generation.

课程表

（北京时间）

课程名称	课程时间		语言	授课教师
材料科学与工程专业英语	星期三	08:00–09:50	英文	赵晓续
地球环境问题与应对	星期二	13:00–14:50	英文	Mikinori Kuwata
固体物理学	星期三 星期五	10:10–12:00 08:00–09:50	英文	陈剑豪 刘雄军
超快激光和光谱	星期五	10:10–12:00	英文	施可彬
生物化学	星期一 星期四	18:40–20:30 15:10–17:00	英文	肖俊宇 陈晓伟 伊成器
遗传学	星期一 星期三	15:10–17:00（单周） 15:10–17:00	英文	宋艳 陆剑
细胞生物学	星期二 星期四	10:10–12:00 08:00–09:50（单周）	英文	李湘盈 陈晓伟 李国强 张莹 陈玥舟
生物数学建模	星期三	18:40–21:30	英文	陶乐天 Jackson Champer

备注：
本手册课程信息仅供参考，请以教师实际授课时公布内容为准。

COURSE SCHEDULE

(All time is Beijing time)

Course name	Course time (Beijing time)		Language	Instructor
Frontiers of Materials Science and Engineering	Wednesday	08:00-09:50	English	ZHAO Xiaoxu
Earth's Environmental Problems and Solutions	Tuesday	13:00-14:50	English	Mikinori Kuwata
Solid State Physics	Wednesday Friday	10:10-12:00 08:00-09:50	English	CHEN Jianhao LIU Xiongjun
Ultrafast Laser and Spectroscopy	Friday	10:10-12:00	English	SHI Kebin
Biochemistry	Monday Thursday	18:40-20:30 15:10-17:00	English	XIAO Junyu CHEN Xiaowei YI Chengqi
Genetics	Monday Wednesday	15:10-17:00 (biweekly) 15:10-17:00	English	SONG Yan LU Jian
Cell Biology	Tuesday Thursday	10:10-12:00 08:00-09:50 (biweekly)	English	LEE Hsiang-Ying CHEN Xiaowei LI Guoqiang ZHANG Ying CHEN Yuezhou
Mathematical Modeling in the Life Sciences	Wednesday	18:40-21:30	English	TAO Louis Jackson Champer

Note:
The contents of this brochure are for reference only and are subject to change.

Course Title

Frontiers of Materials Science and Engineering

材料科学与工程专业英语

Instructor

ZHAO Xiaoxu / 赵晓续

First day of classes: 2024 / 02 / 21
Last day of classes: 2024 / 06 / 05
Course Code: 23200007
Course Credit: 2
Language: English

COURSE DESCRIPTION
课程简介

Objective

This course will introduce fundamentals knowledge of materials science and engineering and focus on the structure, property and process of representative materials such as metals, ceramics, semiconductors, and cutting-edge novel materials and new technologies related to materials science. Major topics are: atomic/molecular structure and chemical bonds in metals and ceramics; crystals and quasicrystals; defects, deformation, strengthening and failure mechanisms in solids; mechanical and electronic properties in materials; nanomaterials; composites; new energy materials; structural analysis of materials; recent research progress and developments in practical applications in the field. This course teaches students to apply professional English skills to describe and understand topics related to materials science.

Pre-requisites / Target audience

No

Assignments
(essay or other forms)

Essay

Evaluation Details

Grades are determined based on academic homework, classroom performance, and mid-term and final exams.

1. Mid-term and final exams (closed-book written exams, assessing understanding and application of professional knowledge points and important concepts, mastery of textbook content, and reading comprehension of relevant literature, constituting 70% of the total course grade)
2. Class participations (literature reading, classroom participation, answering questions, and other regular performances, accounting for 20% of the total grade)
3. Reports (evaluating students' English expression and communication skills, accounting for 10% of the total grade)

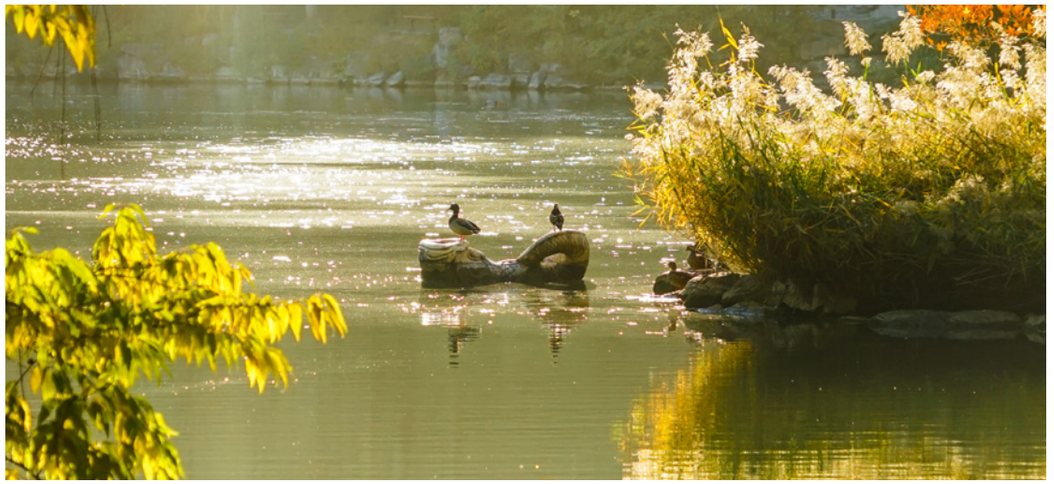
Text Books and Reading Materials

Fundamentals of Materials Science and Engineering, Fifth edition, William D. Callister, Jr.
ISBN 978-7-5025-4178-1, 2002.12

CLASS SCHEDULE

教学大纲

(Subject to adjustment)



Session 1

Introduction of Materials Science & Engineering

Description of the Session

Historical perspective, materials development, recent research progress, advanced materials and technologies, potential applications in materials, electronics, flexible devices, energy and environmental areas

Session 2

Atomic and Molecular Structure

Part 1

Description of the Session

Interaction between atoms, primary and secondary chemical bonds

Session 3

Atomic and Molecular Structure

Part 2

Description of the Session

Interaction between atoms, primary and secondary chemical bonds

Session 4

Metals and Ceramics

Description of the Session

Crystals, polycrystals, quasicrystals, amorphous structures

Session 5

Defects and imperfections in solids

Part 1

Description of the Session

Point, linear and interfacial defects, dislocation movement and interaction, defect engineering, potential application of defects

Session 6

Defects and imperfections in solids

Part 2

Description of the Session

Point, linear and interfacial defects, dislocation movement and interaction, defect engineering, potential application of defects

Session 7

Deformation and strengthening mechanism

Description of the Session

Strengthening methods: grain size reduction, solid-solution, strain hardening

Session 8

Review and midterm exam

Description of the Session

Review of last seven weeks and conduct midterm exam

Session 9

Material properties

Part 1

Description of the Session

Mechanical properties, strength and toughness, electronic and optical properties

Session 10

Material properties

Part 2

Description of the Session

Mechanical properties, strength and toughness, electronic and optical properties

Session 11

Nanomaterials and nanoelectronics

Part 1

Description of the Session

Introduction of nanotechnology, structure and properties of nanomaterials, nano electronics, nanoelectromechanical systems, applications of nanomaterials

Session 12

Nanomaterials and nanoelectronics

Part 2

Description of the Session
Introduction of nanotechnology, structure and properties of nanomaterials, nano electronics, nanoelectromechanical systems, applications of nanomaterials

Session 13
Characterization of Nanomaterials
Part 1

Description of the Session
Introduction of nanotechnology, structure and properties of nanomaterials, nano electronics, nanoelectromechanical systems, applications of nanomaterials

Session 14
Characterization of Nanomaterials
Part 2

Description of the Session
Introduction of nanotechnology, structure and properties of nanomaterials, nano electronics, nanoelectromechanical systems, applications of nanomaterials

Session 15
Special topic and presentation

Description of the Session
Cutting-edge technology progress, student presentation and panel discussions

Session 16
Recent development in materials science and technology

Description of the Session
Emerging applications in various fields such as energy, environmental and electronics; new materials and technologies; recent research progress in the field of materials; future directions

ZHAO Xiaoxu

Dr. Xiaoxu Zhao is currently an Assistant Professor in School of Materials Science & Engineering at Peking University, China. He obtained his B. Eng. (1st Class Honours) from Nanyang Technological University in 2014, and PhD from National University of Singapore in 2018. After graduation, he continued as a Research fellow at National University of Singapore from 2018 to 2020, and joined Nanyang Technological University as a Presidential Postdoc Fellow from 2020 to 2022. His main research interests are using scanning transmission electron microscopy/electron energy loss spectroscopy STEM/EELS to understand the atomic and electronic structure of 2D materials and applying focused electron beam together with in situ heating to engineer the atomic structure of 2D materials. He demonstrated the possibility of fabricating and modifying the edges, dopants, defects, and grain boundaries in 2D quantum materials with atomic precision. A full range of physical properties can be precisely tuned by defect engineering, doping or twisting. Particularly, he applied a new formula to create a fresh atomic library of 2D materials, which were named “ic-2D” to specify that their type was based on the self-intercalation of natural atoms into the gaps between the layers of the material. He published over 120 peer reviewed papers including Nature, Nat. Nanotechnol, Nat. Mater, Nat. Commun., Sci. Adv., etc, with over 8000 citations, h-index 47. He was named in the MIT Technology Review TR35 (Asia-Pacific) 2022.

Course Title

Earth's Environmental Problems and Solutions

地球环境问题与应对

Instructor

Mikinori Kuwata

First day of classes: 2024 / 02 / 20
Last day of classes: 2024 / 06 / 04
Course Code: 00432301
Course Credit: 2
Language: English

COURSE DESCRIPTION
课程简介

Objective

This introductory course will provide an overview of the history, current status, and mitigation strategies for atmospheric chemistry and environment. The course will be comprehensive rather than specific. Students from all the academic disciplines are welcomed to attend.

Pre-requisites / Target audience

Prerequisites/No special requirement
Target audience/All undergraduate students in all disciplines. Students those are not majoring science/engineering are welcomed to attend the course. All the students are assumed to have high school level knowledge about physics and chemistry.

Proceeding of the Course

Lecture by the instructor

Assignments (essay or other forms)

No special assignments except for the quiz.

Evaluation Details

Final quiz (16th week, 100%)

Text Books and Reading Materials

Mark Z. Jacobson, Air Pollution and Global Warming: History, Science, and Solutions 2nd Edition, Cambridge University Press, 1-406, 2012

Academic Integrity

A student should not cheat answers of other students during quiz.

CLASS SCHEDULE
教学大纲

(Subject to adjustment)

Session 1
Atmospheric Chemicals

Description of the Session

Lecture

Purpose: After this session, students will be able to explain about the history of discovery of major atmospheric chemical species of the earth.

Questions

How were ozone at the ground surface and upper atmosphere discovered in the 19th century?

Readings, Websites or Video Clips

Mark Z. Jacobson, Air Pollution and Global Warming: History, Science, and Solutions 2nd Edition, Cambridge University Press, 1-406, 2012 (Chapter 1)

Session 2
Evolution of Earth's atmosphere

Description of the Session

Lecture

Purpose: After this session, students will be able to describe how the chemical composition of the earth's atmosphere evolved since the formation of the planet.

Questions

Why do we have oxygen in the earth's atmosphere? Why is oxygen absent in the atmosphere of Mars and Venues?

Readings, Websites or Video Clips

Mark Z. Jacobson, Air Pollution and Global Warming: History, Science, and Solutions 2nd Edition, Cambridge University Press, 1-406, 2012 (Chapter 2)

Session 3
Structure and composition of the current atmosphere

Description of the Session

Lecture

Purpose: After this session, students will be able to tell the reason why the atmosphere have vertical structures.

Questions

Why can we see a layer of haze from an aircraft?

Readings, Websites or Video Clips

Mark Z. Jacobson, Air Pollution and Global Warming: History, Science, and Solutions 2nd Edition, Cambridge University Press, 1-406, 2012 (Chapter 3)

Session 4
Urban air pollution

Description of the Session

Lecture

Purpose: After this session, students will be able to explain about the reason why nitrogen oxides and hydrocarbons need to be controlled for regulating ozone concentration in urban areas.

Questions

Are there any differences in air pollution during daytime and nighttime? Why?

Readings, Websites or Video Clips

Mark Z. Jacobson, Air Pollution and Global Warming: History, Science, and Solutions 2nd Edition, Cambridge University Press, 1-406, 2012 (Chapter 4)

Session 5
Aerosol particles in the atmosphere

Description of the Session

Lecture

Purpose: After this session, students will be able to describe sources of PM2.5 and PM10.

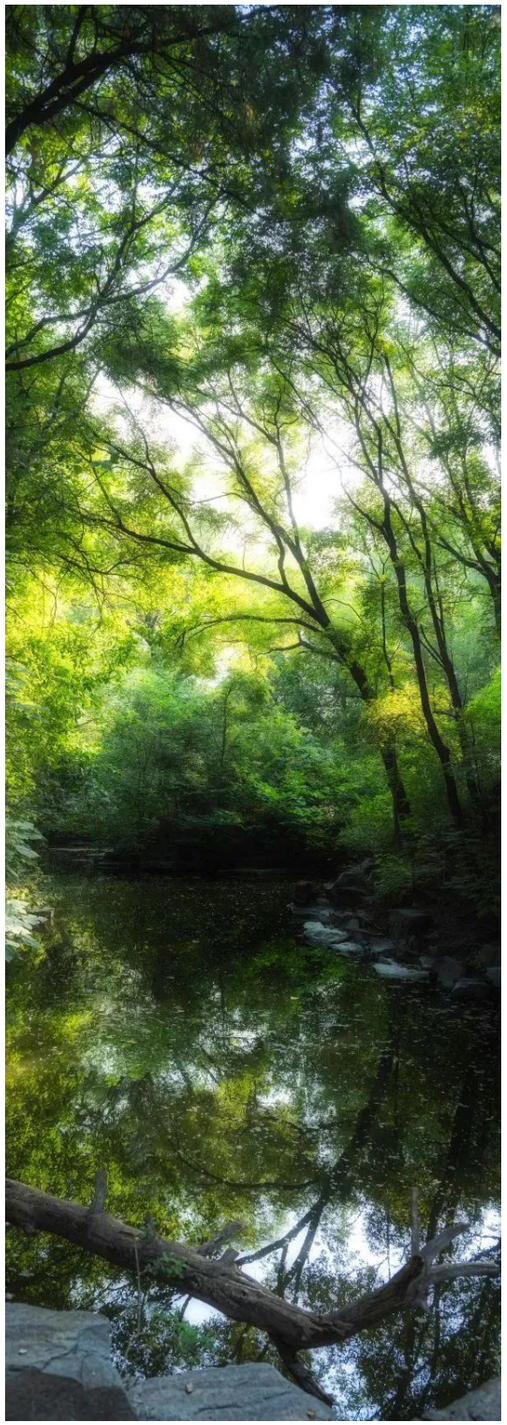
Questions

How are the haze and dust storms different?

Readings, Websites or Video Clips

Mark Z. Jacobson, Air Pollution and Global Warming: History, Science, and Solutions 2nd Edition, Cambridge University Press, 1-406, 2012 (Chapter 5)

Session 6
Meteorology and air pollution



Description of the Session
Lecture
Purpose: After this session, students will be able to explain how atmospheric pollutants are horizontally transported.

Questions
Does China need to concern about atmospheric emission of radioactive materials from Japan when a nuclear accident happens?

Readings, Websites or Video Clips
Mark Z. Jacobson, Air Pollution and Global Warming: History, Science, and Solutions 2nd Edition, Cambridge University Press, 1-406, 2012 (Chapter 6)

Session 7
Atmospheric environment of China

Description of the Session
Lecture
Purpose: After the lecture, students will be able to explain how the atmospheric environment of China has been changing in the last half century, and how the emission control policy of the last decade improved the air quality.

Questions
What needs to be regulated for controlling air quality in Beijing?

Readings, Websites or Video Clips
Zhang, H., Wang S., Hao, J., Wang, X., Wang, S., Chai, F., Li, M.Air pollution and control action in Beijing, Journal of Cleaner Production, 1519-1527, 2016

Session 8
Atmospheric environment and human health

Description of the Session
Lecture
Purpose: After the lecture, students will be able to tell how much air quality influence human health, and how gas/particle phase species in the air influences human health.

Questions
How does PM2.5 influence human health?

Readings, Websites or Video Clips
Lelieveld, J., Evans, J., Fnais, M. et al. The contribution of outdoor air pollution sources to premature mortality on a global scale. Nature 525, 367–371 (2015).

Session 9
Atmospheric radiation and pollution

Description of the Session
Lecture
Purpose: After the lecture, students will be able explain how aerosol particles influence visibility.

Questions
Why is the great smoky mountains ‘smoky’?

Readings, Websites or Video Clips
Mark Z. Jacobson, Air Pollution and Global Warming: History, Science, and Solutions 2nd Edition, Cambridge University Press, 1-406, 2012 (Chapter 7)

Session 10
Regulations for urban air pollution

Description of the Session
Lecture
Purpose: After the lecture, students will be able to explain how the regulations on air pollution control has been developed, and how they have been implemented.

Questions
When has the first regulation on air quality control been issued?

Readings, Websites or Video Clips
Mark Z. Jacobson, Air Pollution and Global Warming: History, Science, and Solutions 2nd Edition, Cambridge University Press, 1-406, 2012 (Chapter 8)

Session 11
Acid rain

Description of the Session
Lecture
Purpose: After the lecture, students will be able to describe the formation mechanisms and environmental impacts of acid rain.

Questions
Why didn’t China experience the issue of acid rain?

Readings, Websites or Video Clips
Mark Z. Jacobson, Air Pollution and Global Warming: History, Science, and Solutions 2nd Edition, Cambridge University Press, 1-406, 2012 (Chapter 10)

Session 12

Stratospheric ozone

Description of the Session

Lecture

Purpose: After the lecture, students will be able to explain the formation mechanisms of the ozone layer (Chapman mechanism).

Questions

Why doesn't short-wave UV from the sun reach the ground surface of the earth?

Readings, Websites or Video Clips

Mark Z. Jacobson, Air Pollution and Global Warming: History, Science, and Solutions 2nd Edition, Cambridge University Press, 1-406, 2012 (Chapter 11)

Session 13

Regulations for ozone depleting substances

Description of the Session

Lecture

Purpose: After this lecture, students will be able to explain how the role of CFCs on ozone hole was discovered, and how its emission been internationally regulated.

Questions

Why do we need to use HCFCs for fridges in our home?

Readings, Websites or Video Clips

Mark Z. Jacobson, Air Pollution and Global Warming: History, Science, and Solutions 2nd Edition, Cambridge University Press, 1-406, 2012 (Chapter 11)

Session 14

The greenhouse effect and climate change

Questions

Lecture

Purpose: After the lecture, students will be able to explain how gas and particulate species in the atmosphere influence ground surface temperature.

Readings, Websites or Video Clips

Mark Z. Jacobson, Air Pollution and Global Warming: History, Science, and Solutions 2nd Edition, Cambridge University Press, 1-406, 2012 (Chapter 12)

Session 15

An example: development of oil palm plantation and environmental issues

Description of the Session

Lecture

Purpose: After this lecture, students will be able to explain how the on-going development of oil palm plantations has been impacting the environment, and how the society tries dealing with it.

Questions

What is oil palm? Why do we need? What are the consequences of the development?

Session 16

Quiz

Description of the Session

Quiz for checking the knowledge and understanding on the contents of the course.

Mikinori Kuwata

I received my bachelor (chemistry) and Ph.D (earth and planetary sciences) degrees at the University of Tokyo, Japan. After graduation, I worked as a postdoctoral fellow at Harvard University in USA for more than 4 years. I served as a faculty member at Nanyang Technological University in Singapore before moving to Peking University.

I have been conducting research on atmospheric chemistry. My expertise is in atmospheric observation and laboratory study of aerosol particles. Currently, my group in Peking university is working on laboratory experiments for understanding physicochemical properties of aerosol particles for understanding their atmospheric impacts. My previous research includes atmospheric observation of aerosol particles, environmental chamber experiments for secondary organic aerosol formation, and study about wildfire haze in southeast Asian countries.

I taught/am teaching the following courses:

Nanyang Technological University in Singapore

Introduction to Atmospheric Chemistry (3rd/4th year undergraduate students)

Geochemistry (3rd/4th year undergraduate students)

Atmospheric Pollution and Climate Change (1st/2nd year undergraduate students)

Research skills in Earth System Science (1st year Ph.D students)

Peking University

Earth's environmental problems and solutions (undergraduate students)

Atmospheric Aerosol (Ph.D students)

大气科学前沿（一）(Ph.D students)

Among above courses, the objective of Atmospheric Pollution and Climate Change is closely related to this course. The course was opened to all the 1st and 2nd year students of the university, including those were majoring science, engineering, policy, and economics. I still maintain good contacts with some students in the course. They are currently majoring environmental science/policy.

Course Title

Solid-State Physics
固体物理学

Instructor

CHEN Jianhao / 陈剑豪

LIU Xiongjun / 刘雄军

First day of classes: 2024 / 02 / 21
Last day of classes: 2024 / 06 / 07
Course Code: 00432510
Course Credit: 4
Language: English

COURSE DESCRIPTION
课程简介

Objective

As a first exposure to the vast subject of solid-state physics, this course aims to develop the core language and elementary principles for describing the microscopic processes that govern the macroscopic phenomena in solid-state materials. We will highlight the key ideas and principles, and leave mathematical sophistication/complication to the more advanced curricula. We will work closely with perfect crystalline materials to introduce the key concepts of structure, symmetry, and wave propagation in periodic systems. The idea of band theory is naturally developed in this context to understand elementary electrodynamics and lattice dynamics, with which the basic thermodynamic and electric properties will be introduced. Building upon these fundamental concepts, selected intermediate to advanced topics of current importance will be discussed, including but not limited to: magnetism, superconductivity, semiconductors, as well as spontaneous symmetry-breaking, geometry, and topology in condensed matter physics.

Pre-requisites /Target audience

Pre-requisites: Quantum Mechanics, Statistical Mechanics
Target audience: Physics Undergraduate

Proceeding of the Course

Oral Lectures by the instructor

Assignments (essay or other forms)

Homework, assigned weekly

Evaluation Details

Homework 40%
Midterm Exam 20% (closed book)
Final Exam 40% (closed book)

Text Books and Reading Materials

Solid State Physics by Neil Ashcroft and David Mermin

CLASS SCHEDULE
教学大纲

(Subject to adjustment)

Session 1
Structure of Solids
(4 classes/2 weeks) Date: 2024.02.21-03.01

Description of the Session

Lecturer: Jian-Hao Chen

Introduction to the following key concepts of the structure of solids:

- Basic crystal structure: Bravais lattice, Miller indices etc.
- Diffraction and reciprocal lattices
- Lattice symmetry
- Crystal Binding

Session 2
Electronic band structure
(4 classes/2 weeks) Date: 2024.03.06-03.15

Description of the Session

Lecturer: Xiongjun Liu

Introduction to the key concepts of the electronic energy band:

- Bloch Theorem and Bloch Bands
- Weak periodic potential; Band gap and Brillouin zone
- Tight-binding approximation
- (1+1)d Dirac model; Topological band; Topological soliton; Generalizations
- Other methods to compute band structures

Session 3
Semiclassical Transport
(6 classes/3 weeks) Date: 2024.03.20-04.05

Description of the Session

Lecturer: Jian-Hao Chen

Introduction to transport phenomena and the semi-classical theory of transport in solids:

- Wave packet dynamics;
- Equation of motion; anomalous velocity;
- Boltzmann equation;
- Berry phase and Hall effect;
- Impurity scattering;
- Localizations.

Session 4
Lattice Dynamics
(6 classes/3 weeks) Date: 2024.04.10-04.26

Description of the Session

Lecturer: Jian-Hao Chen

Introduction to the key concepts of lattice dynamics in solids:

- Classical Harmonic oscillators;
- 1D atomics chains;
- Quantum Harmonic lattice;
- Phonons and thermodynamics;
- Lattice heat capacity.

Session 5
Magnetism
(6 classes/3 weeks) Date: 2024.05.01-05.17

Description of the Session

Lecturer: Xiongjun Liu

Introduction to key concepts and phenomena of magnetism:

- Magnetic properties: Diamagnetism & Paramagnetism
- Magnetic structures and Heisenberg models
- Magnetic phases; Mean-field theories; Spontaneous symmetry breaking;
- Magnetic excitations; Spin waves.

Session 6
Superconductivity
(6 classes/3 weeks) Date: 2024.05.22-06.07

Description of the Session

Lecturer: Xiongjun Liu

Introduction to the key concepts of superconductivity:

- Phenomenology and Ginzburg–Landau theory;
- Cooper instability;
- Introduction to Bardeen-Cooper-Schrieffer theory;
- Recent progresses; Topological superconductivity.

CHEN Jianhao

Prof. Jian-Hao Chen received his Bachelor's degree in Physics from Zhejiang University in Hangzhou, China, and his Ph.D. degree in Physics from the University of Maryland at College Park, United States. He then worked as a postdoctoral researcher at the University of Maryland at College Park and at the University of California Berkeley in the United States before joining Peking University in Beijing, China at 2013. He is now the principle investigator of the Laboratory for Nanoelectronics and in-situ Quantum Transport, deputy director of the Key Laboratory for the Physics and Chemistry of Nanodevices at Peking University. He has ten years of teaching experience in Physics, and seven years of teaching experience in undergraduate Solid-State Physics in English. His research interest focuses on the physics of low-dimensional topological, superconducting and magnetic materials as well as the construction of novel low-dimensional mesoscopic devices with potential applications. He is also specialized in the design and fabrication of in-situ quantum measurement instruments which can control the surface absorption of low-dimensional mesoscopic devices during quantum transport measurements in low-temperature, strong magnetic field and ultra-high vacuum environment. He has published over 60 papers with an SCI citation of over 8200; he also has 10 patents in the field of instrumentation and novel device structures. He was ranked as one of the Most Cited Chinese Researchers by Elsevier in the consecutive years of 2021 and 2022.

LIU Xiongjun

Xiong-Jun Liu is currently a Boya Distinguished Professor at Peking University. He graduated with Ph.D. in Texas A&M University in 2011, and then worked as postdoctoral fellow in JQI and CMTC at University of Maryland, Institute for Advanced Study at Hong Kong University of Science and Technology and Department of Physics at MIT from 2011 to 2014. He joined the faculty of International Center for Quantum Materials and School of Physics at Peking University in Sep 2014, was tenured in Jul 2018, and further promoted to a full professor in 2019. Prof. Liu has been working in cold atom physics and condensed matter theory, including topological superconductivity and topological quantum computation, synthetic gauge fields, quantum thermalization and localization physics, non-equilibrium quantum dynamics, strongly correlated topological matter, etc. He received the AAPPS Chen Ning Yang Award (2019) and the CPS Chou Pei Yuan Prize for fundamental physics (2023).

Course Title

Ultrafast Laser and Spectroscopy
超快激光和光谱

Instructor

SHI Kebin / 施可彬

First day of classes: Friday of the first semester week, Spring Semester
Last day of classes: Friday of the last semester week, Spring Semester
Course Code: 00405645
Course Credit: 2
Language: English

COURSE DESCRIPTION
课程简介

Objective

The primary purpose of this course is to lay the foundation for first-year graduate students and senior undergraduate students, who are interested in ultrafast optics including ultra-short laser/spectroscopy technologies and their applications in various scientific fields. Course content will include fundamental trainings for both ultrafast optics theory and practical technologies.

Pre-requisites /Target audience

College Physics/Optics, Electromagnetic field and Electrodynamics. Target Audience: first-year graduate students and senior undergraduate students

Proceeding of the Course

In class lectures with one middle term exam (open book)

Assignments
(essay or other forms)

Homework for every two weeks, one final written term paper.

Evaluation Details

40% homework, 30% mid-term exam (open book), 30% final term paper on literature reading or final project

Text Books and Reading Materials

Text book: Jean Diels & Wolfgang Rudolph, Ultrafast Optical Pulse Phenomena, Academic Press (2006)
Extended reading materials including scientific papers and reports.

CLASS SCHEDULE

教学大纲

(Subject to adjustment)

Session 1

Fundamental concepts I

Description of the Session

Fundamentals of laser pulse, complex analytical signal and its application in ultrafast optics I

Session 2

Fundamental concepts II

Description of the Session

Fundamentals of laser pulse, complex analytical signal and its application in ultrafast optics II

Session 3

Fundamental concepts III

Description of the Session

Fundamentals of laser pulse, complex analytical signal and its application in ultrafast optics III

Session 4

Propagation law I

Description of the Session

Propagation of ultrafast laser pulse I

Session 5

Propagation law II

Description of the Session

Propagation of ultrafast laser pulse II

Session 6

Dispersion: a time domain analogy of diffraction

Description of the Session

Phase modulation in ultrafast optics: dispersion and diffraction

Session 7

Optical devices in ultrafast optics I

Description of the Session

Dispersion property of optical components used frequently used in ultrafast optics I

Session 8

Optical devices in ultrafast optics II

Description of the Session

Dispersion property of optical components used frequently used in ultrafast optics II

Session 9

Optical devices in ultrafast optics III

Description of the Session

Dispersion property of optical components used frequently used in ultrafast optics III

Session 10

Mode locking mechanism I

Description of the Session

Theory and design of mode-locking laser I

Session 11

Mode locking mechanism II

Description of the Session

Theory and design of mode-locking laser II

Session 12
Laser pulse measurements I

Description of the Session
Characterization techniques for ultrafast laser pulse I

Session 13
Laser pulse measurements II

Description of the Session
Characterization techniques for ultrafast laser pulse II

Session 14
Nonlinear interactions in ultrafast optics

Description of the Session
Introduction to ultrafast-nonlinear optics

Session 15
Applications I

Description of the Session
Ultrafast laser spectroscopy technologies: time resolved framework, pump-probe technique, THz techniques

Session 16
Applications II

Description of the Session
Optical imaging technologies based on ultrafast optics

SHI Kebin

Dr. Kebin Shi received his Bachelor's and Master's degree from Nankai University in 1998 and 2001 respectively. He received his Ph.D degree in Electrical Engineering at the Pennsylvania State University in 2007. Dr. Shi joined faculty members in the Institute of Modern Optics at Peking University in May 2011. His research focuses on developing novel photonic systems and devices based on ultrafast/nonlinear optical principles for spectroscopy, imaging and applications. His recent research interests include super-resolution imaging, nonlinear holography and femto-second frequency comb metrology. He currently serves as a co-chair of conference committee for Ultrafast Imaging and Spectroscopy Conference at SPIE Optics + Photonics annual meeting. In 2013, Dr. Shi was awarded “National Natural Science Funds for Excellent Young Scholar” by National Natural Science Foundation of China (NNSFC). He has authored or coauthored more than 100 refereed journal papers with over 2400 citations (h-index: 28), and has delivered over 50 invited talks/ seminars in international or domestic conferences/universities. His scientific achievements also include 13 granted patents.

Course Title

Biochemistry
生物化学

Instructor

XIAO Junyu / 肖俊宇

CHEN Xiaowei / 陈晓伟

YI Chengqi / 伊成器

First day of classes: 2024 / 02 / 19
Last day of classes: 2024 / 06 / 06
Course Code: 01139630
Course Credit: 4
Language: English

COURSE DESCRIPTION
课程简介

Objective

Biochemistry is the study of the chemical substances and processes that occur in animals, plants and microorganisms, and of the changes they undergo during development. Biochemistry is an essential discipline, and has become the foundation for understanding all biological processes. The course aims to help students learn how to apply concept of chemistry or physics to understand core principles of Biochemistry, along with the history of biochemistry.

Pre-requisites /Target audience

Second-year undergraduate who have learned organic chemistry, analytic chemistry, fundamentals of physics and mathematics.

Proceeding of the Course

The Course will basically follow the textbook, and will be delivered through lecture slides.

Evaluation Details

Total points are 100, being divided into four parts including in-class tests (10%), mid-term exam (45%), final exam (45%). Additional assignments may be announced during the course.

Text Books and Reading Materials

Lehninger Principles of Biochemistry 8th Edition

CLASS SCHEDULE

教学大纲

(Subject to adjustment)

Session 1
Amino acids, peptides and proteins

Session 2
Protein structure and function

Session 3
Enzymes

Session 4
Carbohydrates and glycobiology

Session 5
Nucleotides and nucleic acids

Session 6
Lipids

Session 7
Principle of bioenergetics

Session 8
Glycolysis, gluconeogenesis, pentose phosphate pathway

Session 9
The citric acid cycle

Session 10
Fatty acid catabolism

Session 11
Amino acid oxidation and production of urea

Session 12
Oxidative phosphorylation

Session 13
Lipid biosynthesis

Session 14
Biosynthesis of amino acids and related molecules

Session 15
Biosynthesis of nucleotides

Session 16
Hormonal regulation and Integration of mammalian metabolism

XIAO Junyu

Junyu Xiao earned his BS degree from Peking University in 2002 and his PhD in 2008 from the University of Michigan. He then completed postdoctoral training at the University of California San Diego before establishing his independent group at Peking University in 2014. Currently, he holds the position of Associate Professor (with tenure) at the School of Life Sciences and serves as the Principal Investigator of the Peking-Tsinghua Center for Life Sciences. Dr. Xiao's primary research focuses on comprehending the structure and function of immune molecules, particularly human immunoglobulins. Leveraging cryo-electron microscopy technology, his group has successfully characterized the core structures of secretory IgM and IgA, laying the groundwork for a deeper understanding of their function and the potential for structure-based engineering of these vital molecules.

CHEN Xiaowei

Xiao-Wei Chen obtained his BS and BA from Peking University, and completed his PhD and postdoctoral training at the University of Michigan. He was recruited back to the Peking University in 2014. Currently, he holds the position of Professor at the College of Future Technology and serves as the Principal Investigator of the Peking-Tsinghua Joint Center for Life Sciences. He is the recipient of the Young Investigator Award from the Chinese American Diabetes Association and Special Recognition Award from the Society of Heart and Vascular Metabolism, as well as the Earl Stadtman Scholar finalist from the National Institute of Health, USA and the Distinguished Young Scholar Award from the National Natural Science Foundation, China. He serves as an associate editor at the *Biochemical Journal* and on the editorial board of *Cell Metabolism, Life Metabolism* and *Journal of Lipid Research*. His work focuses on the genetics and cell biology of lipoprotein biology and lipid homeostasis, particularly by elucidating a receptor-mediated export program for the lipoproteins and identifying the long-sought biogenic lipid scramblase.

YI Chengqi

Chengqi Yi received his BS degree from University of Science and Technology of China in 2005 and his doctor's degree from the university of Chicago in 2010. From 2010 to 2011, he worked as a postdoctoral fellow in the university of Chicago. In 2012, he returned to the Life Science Institute of Peking University and joined the National Key Laboratory. In the same year, he was selected by the “Program of Thousand Youth Talents” of the Organization Department of the Central Committee of China; In 2018, he was awarded the “The National Science Fund for Distinguished Young Scholars” of China. In 2019, he was awarded the 4th National Special Support Program for High-Level Personnel Recruitment. Through the development of new techniques and new methods in chemical biology, Dr. Yi and his group are committed to the mechanism study of nucleic acid chemical modification to regulate important life processes. So far, they have developed a number of novel DNA/RNA-modified original technologies, and have extended the new direction of research leaded by Chinese scientists in the field of transcriptomics.

Course Title

Genetics
遗传学

Instructor

SONG Yan / 宋艳

LU Jian / 陆剑

First day of classes: 2024 / 02 / 19
Last day of classes: 2024 / 06 / 03
Course Code: 01130200
Course Credit: 3
Language: English

COURSE DESCRIPTION
课程简介

Objective

This course discusses the principles of genetics with application to the study of biological function at the level of molecules, cells, and multicellular organisms, including humans. The topics include: structure and function of genes, chromosomes and genomes, biological variation resulting from recombination, mutation, and selection, population genetics, use of genetic methods to analyze protein function, gene regulation and inherited disease.

Pre-requisites /Target audience

Biochemistry

Assignments
(essay or other forms)

Problem sets

Evaluation Details

The evaluation is based the student's performance on problem sets, involvement in class discussion and the final exam.

Text Books and Reading Materials

Reference book: Leland Hartwell et al., Genetics: From Genes to Genomes, 6th Edition, McGraw-Hill Education, New York, 2017.

CLASS SCHEDULE
教学大纲

(Subject to adjustment)

Introduction

I. A brief history of modern genetics
II. What is genetics? – the science of heredity
III. Why do we study genetics?
IV. The themes of modern genetics

Chapter I
Mendel's Law of Inheritance

I. Mendel's breakthrough
II. Extension to Mendel's laws

Chapter II
The Chromosome Theory of Inheritance and Linkage Analysis

I. The chromosome theory of inheritance
II. Linkage and recombination
III. Mapping: locating genes along a chromosome
IV. Mitotic recombination and genetic mosaics
V. Mechanism of homologous recombination and gene conversion

Chapter III
The Concepts of Gene and Mutation

I. The Conception of Gene
II. Functional dissection of a gene through mutation
III. Somatic mutation and the genetics of cancer

Chapter IV
Chromosome Aberration

I. The Eukaryotic Chromosomes
II. Chromosomal Rearrangements
III. Changes in Chromosome Number

Lecture. Genetic Application and New Model Systems

Chapter V
Genome Analysis

I. Basic concepts of genomics and sequence map
II. The Human Genome Project and major insights from human genome

III. Techniques in genome sequencing, gene family and evolution

Chapter VI
Genome Analysis in Prokaryotes

I. Basic knowledge of bacteria and meta-genomics
II. Gene transfer in bacteria: transformation, conjugation, and transduction
III. Gene regulation in prokaryotes: the operon theory

Chapter VII
Genome Analysis in Eukaryotes

I. Differences between prokaryotes and eukaryotes in gene expression
II. Gene regulation in eukaryotes: cis elements and trans factors
III. A comprehensive example of gene regulation: sex determination in Drosophila

Chapter VIII
ncRNA and epigenetics

I. Mechanism of small RNA: miRNA, siRNA, piRNA and RNAi
II. Basic concepts of epigenetics: histone codes, DNA methylation, positive effect variegation
III. Understanding epigenetics: X-inactivation and genomic imprinting

Chapter IX
Human Disease and Genetics

I. Different types of common genetic diseases
II. Strategies to look for a disease-causing gene: candidate gene approach and positional cloning
III. Important concepts in genetic diseases: dominance, penetrance, expressivity and LOD score

Chapter X
Gene Function and Development

I. Concepts of developmental genetics
II. Using mutations to dissect development
III. Gene interactions

Chapter XI
Population Genetics and Molecular Evolution

I. Evolution: the modern evolutionary synthesis
II. Mutation: types, causes and consequences, male driven evolution
III. Population genetics: Hardy-Weinberg equilibrium and natural selection

Key Concepts

Genetics; Heredity; Variation; Gene Linkage; Mutation; Chromosome aberration; Gene regulation; Complementation; Epistasis; Dominant negative effect; Redundancy; Pleiotropy; Balancer chromosome; Mitotic recombination; Dosage compensation; Penetrance; Position-effect variegation; Genomic imprinting; Next-generation sequencing; Positional cloning; GWAS; Penetrance; Darwinian selection; Male-driven evolution

SONG Yan

Dr. Yan Song is Vice Dean & Associate Professor (with tenure) at the School of Life Sciences and a Principal Investigator at Peking-Tsinghua Joint Center for Life Sciences at Peking University (PKU). She received her PhD in molecular genetics from Duke University and completed her postdoctoral training at Stanford University. In the end of 2012, she joined the faculty of PKU to start her independent research group. Combining powerful fly genetics and state-of-the-art imaging with cell biology and biochemical approaches, her research group uses fruit flies, mice, and human cell lines to decipher the secrets of stem cell fate specification and commitment in development and disease. Her group currently focuses on understanding how timely cell fate commitment is achieved and how temporal and spatial cues are integrated to dictate cell fate/identity in stem cell lineages.

LU Jian

Dr. Jian Lu is a professor (with tenure) & doctoral supervisor at the School of Life Sciences at Peking University, the Yangtze River Scholar Professor, an overseas high-level young talent, and the chief scientist of a national key project. He received his PhD in evolutionary biology from the University of Chicago and completed his postdoctoral training at Cornell University. In 2013, he joined Peking University as a principal investigator. He has long been devoted to research in molecular evolution and genomics, exploring the evolutionary patterns of genomic sequences and gene regulatory networks. He has published a total of 55 papers, which have been cited over 7,000 times. In the past five years, he has made significant breakthroughs in the frontier field of "mechanisms and evolutionary drivers of protein translation regulation". He has elucidated the functions and sequence evolution patterns of three types of elements/factors in protein translation regulation: upstream open reading frames (uORFs), non-coding small RNAs, and RNA editing. He has established the association between translation regulation and diseases, promoting further development and improvement of evolutionary theory. During the fight against the COVID-19 pandemic, he has utilized his expertise in evolutionary genomics. By analyzing the accumulating information on viral genomic variations from around the world, he and his collaborators were the first to discover the existence of two major lineages of the SARS-CoV-2, named "L" and "S". They have established comprehensive naming rules for sub-lineages and revealed the evolutionary patterns of the virus genome variations. They have also clarified the impact of early mutations on pathogenicity, providing important references for the formulation of scientifically-based anti-epidemic policies.

Course Title

Cell Biology
细胞生物学

Instructor

LEE Hsiang-Ying / 李湘盈

CHEN Xiaowei / 陈晓伟

LI Guoqiang / 李国强

ZHANG Ying / 张莹

CHEN Yuezhou / 陈玥舟

First day of classes: 2024 / 02 / 20
Last day of classes: 2024 / 06 / 04
Course Code: 01130150
Course Credit: 3
Language: English

COURSE DESCRIPTION
课程简介

Objective

The course aims to guide students through a comprehensive exploration of cell biology, focusing on the intricacies of cell structure, function, and dynamics. It will delve into the various aspects of cellular life, including the diversity of cells, cytoskeletal architecture, biomembrane functions, signaling pathways, and the regulatory mechanisms of the cell cycle, equipping students with a deep understanding of cellular principles and their practical implications in scientific research and application.

Pre-requisites / Target audience

This course is primarily designed for undergraduate students majoring in Biology. It is also suitable for any students who have an interest in the field of cell biology and wish to gain a foundational understanding of cellular structures, functions, and biological processes.

Proceeding of the Course

Weekly topics aligned with chapters from "Molecular Biology of the Cell" (Alberts et al., 7th edition)

Assignments (essay or other forms)

2 homework assignments

Evaluation Details

Mid-term exam (35%), final exam (35%), and homework (30%)

Text Books and Reading Materials

The course materials include a variety of resources prepared by the instructors to facilitate learning, encompassing PowerPoint slides that outline key concepts and illustrate complex biological phenomena. The central text that complements the course is "Molecular Biology of the Cell" by Alberts et al., in its 7th edition, which is recommended for detailed reading to support the lectures and enhance students' understanding of cell biology.

CLASS SCHEDULE
教学大纲

(Subject to adjustment)

Session 1
Uniformity and Diversity of the Cell

Description of the Session

This class will explore the paradoxical nature of cellular biology, where cells exhibit remarkable similarity in chemical and physical processes but also possess unique characteristics that contribute to the diversity of life. This course would delve into the fundamental components and functions shared by all cells, such as genetic material and metabolic pathways, while also examining how variations in these commonalities give rise to the distinct attributes of different cell types across various species. Students would engage in understanding the core principles that govern cellular operations and the specialized adaptations that enable cells to fulfill diverse biological roles.

Questions

1. What are the core structures and functions common to all cells, and how do they support life?
2. How do cellular differences manifest across species and what evolutionary advantages do they confer?
3. In what ways do universal cellular processes underpin our understanding of biology?

4. How do cells adapt their structures and functions to different environmental pressures?

Readings, Websites or Video Clips

Chapter 1 of "Molecular Biology of the Cell" by Alberts et al., 7th edition

Session 2
Techniques and Methods in Cell and Molecular Biology

Description of the Session

Progress in science is often driven by advances in technology. In this session, we will present some of the principal methods used to study cells and their molecular components, including how to disrupt cells and isolate components, how to determine structure and function of protein, and how to copy and read information from the DNA. We will cover several milestone technologies that have transformed cellular and molecular biology. Students will learn the general principles of solving biological questions with suitable technologies.

Questions

1. Which technology in this session inspired you most and why?
2. What technologies do you think are most desired in future to solve critical biology questions you would care?

Readings, Websites or Video Clips

Chapter 8 of "Molecular Biology of the Cell" by Alberts et al., 7th edition

Session 3
The Cytoskeleton

Description of the Session

This class would explore the complex network of fibers that provide structural support for cells. This course would cover the composition, functions, and dynamics of the cytoskeleton's major components: microfilaments, intermediate filaments, and microtubules. Students would learn how the cytoskeleton contributes to cell shape, enables intracellular transport, and orchestrates cell movement and division. The class would also discuss the role of the cytoskeleton in health and disease, particularly in the context of cellular signaling pathways and disease states like cancer.

Questions

1. What are the structural components of the cytoskeleton, and how are they organized within the cell?
2. How does the cytoskeleton contribute to cell movement and shape?
3. In what ways do the cytoskeleton's elements interact with other cellular components?
4. How is the cytoskeleton involved in cellular processes like transport, signaling, and division?
5. What are the implications of cytoskeletal dysfunction in diseases such as cancer?

Readings, Websites or Video Clips

Chapter 16 of "Molecular Biology of the Cell" by Alberts et al., 7th edition

Session 4
Biomembranes and the movement of substances across membranes

Description of the Session

This class would delve into the structure, function, and critical importance of biomembranes in cellular processes. It would explore the mechanisms of substance transport, including diffusion, osmosis, active transport, and vesicular trafficking, with a

focus on the regulatory roles membranes play in homeostasis and cell signaling. Students would engage in understanding the physicochemical principles underlying membrane dynamics and their applications in biotechnology and medicine.

Questions

1. What are the structural components of biomembranes, and how do they contribute to membrane function?
2. How do different substances traverse cell membranes, and what mechanisms control their movement?
3. What roles do transport proteins play in the selective permeability of membranes?
4. How do cells regulate the movement of ions and molecules in response to environmental changes?
5. What are the implications of membrane transport mechanisms in medical and biotechnological fields?

Readings, Websites or Video Clips

Chapters 10&11 of "Molecular Biology of the Cell" by Alberts et al., 7th edition

Session 5

Endomembrane system

Description of the Session

This class will investigate the interconnected network of membranes that compartmentalize the cell, providing distinct environments for different cellular processes. Topics will include the structure and function of the endoplasmic reticulum, Golgi apparatus, lysosomes, and vacuoles, along with vesicle transport and membrane biogenesis. Students will explore how the endomembrane system contributes to protein synthesis, processing, and trafficking, as well as its role in cell metabolism and signaling.

Questions

1. How does the endoplasmic reticulum function in protein synthesis and lipid metabolism?
2. What is the role of the Golgi apparatus in protein modification and sorting?
3. How do lysosomes and vacuoles contribute to cellular digestion and storage?
4. What mechanisms govern vesicular transport between different components of the endomembrane system?
5. How does the endomembrane system coordinate with other cellular structures in maintaining cell homeostasis and responding to signals?

Readings, Websites or Video Clips

Chapter 12 of "Molecular Biology of the Cell" by Alberts et al., 7th edition

Session 6

Protein Sorting and Membrane Trafficking

Description of the Session

This class would cover the cellular mechanisms that direct proteins to their proper destinations within or outside the cell. It will explore the sorting signals that determine protein destinations, the vesicular transport systems, and the molecular machinery involved in the fusion and fission of transport vesicles. Additionally, the course would discuss the physiological consequences of these processes, including the impact on cellular communication, immune responses, and disease states when these pathways malfunction.

Questions

1. How are proteins targeted to specific cellular compartments?
2. What are the roles of vesicular transport in protein sorting?

3. How do cells ensure that proteins reach their correct destinations?
4. What molecular mechanisms facilitate the budding and fusion of transport vesicles?
5. How do errors in protein sorting and trafficking contribute to diseases?

Readings, Websites or Video Clips

Chapter 13 of "Molecular Biology of the Cell" by Alberts et al., 7th edition

Session 7

Midterm exam

Description of the Session

The exam will encompass the material presented from the first to the sixth week of the course.

Session 8

Nucleus, Chromosomes and Control of Gene Expression

Description of the Session

Life depends on the ability of cells to store, retrieve, and translate the genetic instructions required to make and maintain a living organism. In this session, we will describe the structure and function of DNA to store and pass hereditary information, the multi-scale compaction of DNA into chromosome, the chromatin structure and function that could impact gene expression, and how the DNA is evolved across different organisms. Students will learn the uniqueness of DNA as hereditary material and think about utilizing these features in research and biomedicine.

The DNA in genomes does not direct protein synthesis itself, but instead uses RNA as an intermediary, and the process is highly regulated to enable a subset of genes to be selectively expressed in each cell. In this session, we will focus on how cells read the genome with the fundamental principle of central dogma. We will dissect the step pathways from DNA to protein, including the structure and function of RNA and the modifications of RNA generation and processing. We will also learn the general rules and mechanisms that enable a subset of genes to be selectively expressed in each cell at many levels. Students will learn the complexity of the genome as well as the basic principles in decoding the genome information.

Questions

1. What are the unique features of DNA double helix structure that make DNA as hereditary material?
2. Describe the hierarchical packaging of DNA into the chromosomes.
3. The core histones are covalently modified at many different sites. Could you please summarize at least 3 general features of histone modifications?
4. What are the major differences between DNA and RNA molecules?
5. RNA is the key player in the central dogma. What process of RNA amplify the complexity of the gene expression outputs?
6. What are the major differences between RNAi and CRISPR technologies?

Readings, Websites or Video Clips

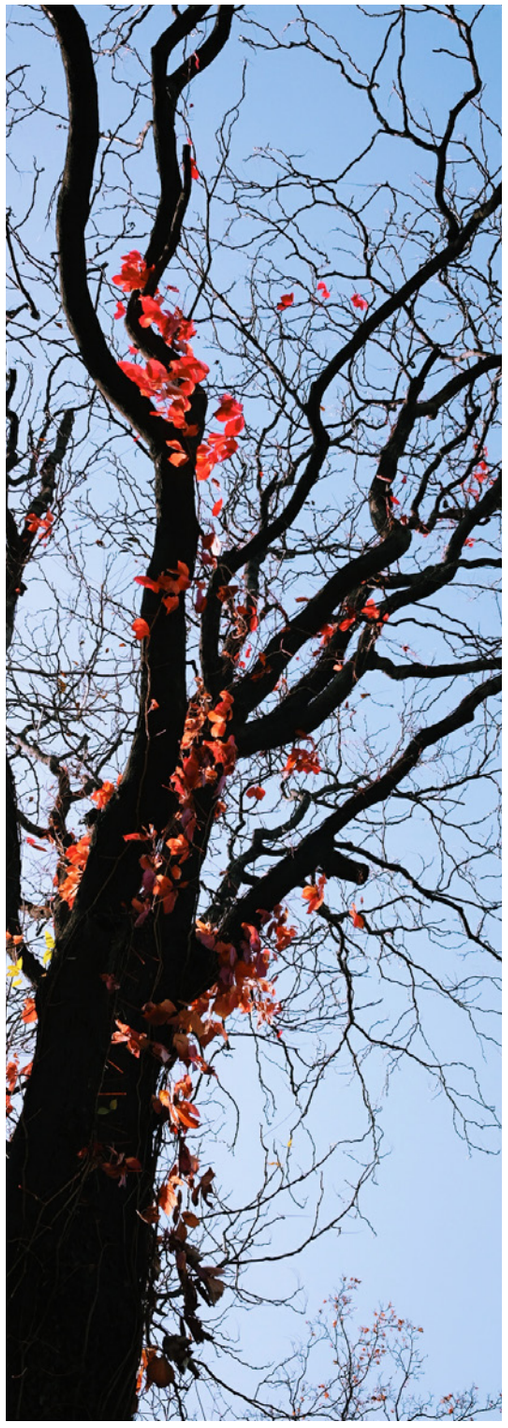
Chapters 4,6,7 of "Molecular Biology of the Cell" by Alberts et al., 7th edition

Session 9

Cell Signaling I

Description of the Session

This class will introduce the basics of cell signaling,



the complex system of communication that governs basic cellular activities and coordinates cell actions. It will cover the fundamentals of signal transduction, signaling molecules, receptors, and the concept of signaling cascades. The course aims to provide an understanding of how cells perceive and respond to their microenvironment.

Questions

1. How do cells interpret and respond to different types of signals?
2. What are the roles of receptors and second messengers in cell signaling?
3. How do signal transduction pathways alter cellular functions?

Readings, Websites or Video Clips

Chapter 15 of "Molecular Biology of the Cell" by Alberts et al., 7th edition

Session 10

Cell Signaling II

Description of the Session

Expanding on foundational knowledge, this class focuses on specific signaling pathways including receptor tyrosine kinases (RTKs) and G protein-coupled receptors (GPCRs). We will discuss the integration of signals at the cellular level, long-term effects, and the alterations in signaling pathways that lead to diseases. Advanced techniques for studying cell signaling and current research in the field will also be covered.

Questions

1. What are the specific functions and mechanisms of receptor tyrosine kinases (RTKs) and G protein-coupled receptors (GPCRs) in cell signaling?
2. How is signaling specificity achieved through these pathways?
3. What are the consequences of dysregulation in RTK and GPCR pathways in disease contexts?

Readings, Websites or Video Clips

Chapter 15 of "Molecular Biology of the Cell" by Alberts et al., 7th edition

Session 11

The Cell Cycle

Description of the Session

The cycle of duplication and division to make a new cell, is the essential mechanism by which all living things reproduce. In this class, we will study the key events of the cell cycle and how these processes are tightly controlled. We will first consider the basic principles of the cell-cycle control system and discuss the coordinated work by the protein components to time and execute events of the cell cycle. Next, we will study the elegant mechanisms by which the cell-cycle control system triggers different events of the cycle and make sure this process happens only once per cycle, and describe the key mechanisms orchestrate events of mitosis and cytokinesis. Finally, we will discuss the mechanisms governing cell division and cell growth, and consider how these two events are coordinated to maintain proper cell size.

Questions

1. What is the cell-cycle control system, what are the protein components of the system, and how do they regulate the different events of the cell cycle?
2. What is happening within each of the major stages of the cell cycle?
3. How extracellular signals govern the rates of cell growth and division, how these two processes are coordinated?

Readings, Websites or Video Clips

Chapter 17 of "Molecular Biology of the Cell" by Alberts et al., 7th edition

Session 12

Cell Death

Description of the Session

Cells that are no longer needed or are a threat to the organism are destroyed by a tightly regulated molecular pathway of cell suicide process named programmed cell death (PCD). Various forms of PCD play critical roles in controlling development, tissue homeostasis, as well as disease progression. This class will begin with a brief overview of distinct types of cell death, followed by discussion of their functions, molecular mechanisms and their regulations in animals. The immune silent noninflammatory apoptosis, and inflammatory forms of cell death, including pyroptosis, necroptosis, and ferroptosis will be discussed and compared in detail. The nonprogrammed form of cell death, necrosis, will also be discussed.

Questions

1. What are the different types of cell death, including PCD and non-PCD?
2. What are the molecular mechanisms and regulations of different forms of PCD?
3. How excessive or insufficient PCD can contribute to human diseases?

Readings, Websites or Video Clips

Chapter 18 of "Molecular Biology of the Cell" by Alberts et al., 7th edition

Session 13

Cell Connection

Description of the Session

Cells are connecting with each other in a multicellular organism. The making and breaking of the attachments between cells and the modeling

of the extracellular matrix govern the way cells move within the organism. In this session, we will learn the basic components and structure of cell-cell junctions, the structure and function of extracellular matrix, and the cell-matrix junctions. We will also dissect the underlying players and mechanisms guiding the connections between cells and matrix. Students will learn that cells are in social interactions with each other and could withstand and respond to the various external signals and forces.

Questions

1. What are the major differences in cell connections between connective tissues and epithelial tissues?
2. What are the regulatory mechanisms that control the rearrangement of cell–cell junctions in epithelia during early development?

Readings, Websites or Video Clips

Chapter 19 of "Molecular Biology of the Cell" by Alberts et al., 7th edition

Session 14

Cancer

Description of the Session

Cancer cells break the most basic rules of cell behavior by which multicellular organisms are built and maintained, which help to reveal what the normal rules are and how they are enforced. In this session, we will learn the general features that distinguish it from normal cells, describe the natural history of the disease from a cellular standpoint, the molecular changes that make a cell cancerous, and how our enhanced understanding of the molecular basis of cancer is leading to improved methods for its prevention and treatment. Students will learn what cancer is and the genetic and environmental drivers behind cancer genesis.

Questions

1. What is the Warburg effects?
2. What are the hallmarks of cancer?
3. What is synthetic lethality? Please show one example of synthetic lethality in cancer drug development.

Readings, Websites or Video Clips

Chapter 20 of "Molecular Biology of the Cell" by Alberts et al., 7th edition

Session 15

Cell Differentiation

Description of the Session

The adult body is a structure in dynamic equilibrium, where new cells are continually being born, differentiating, and dying. In this session, we focus on the homeostatic mechanisms that continue throughout life. We will illustrate some of the diversity of specialized cell types and see how they work together to perform their tasks. We then focus on the stem cells and learn the unique features of them. We will also discuss how stem cells can be generated and manipulated artificially. Students will learn the basic concept of stemness and differentiation, and think about how to utilizing these features for purposes of repair and regeneration.

Questions

1. What is the fundamental molecular difference that distinguishes a stem cell?
2. What is Lateral inhibition? How cells using the Lateral inhibition to specify cell types between neighbors?
3. What are the scientific mechanisms behind the iPSCs generation?

Readings, Websites or Video Clips

Chapter 22 of "Molecular Biology of the Cell" by Alberts et al., 7th edition

Session 16

The Immune System

Description of the Session

The immune system is a complex network of cells, tissues, and organs that work together to defend the host from pathogen infections and other foreign antigens. This session on the immune system aims to provide students with a comprehensive understanding of its structure and functions. Throughout the course, students will gain insights into how the immune system identifies and responds to a wide array of pathogens through both innate and adaptive immunity mechanisms. The curriculum includes vital subjects about immune regulation, the principle and significance of vaccination, as well as the exploration of immune-related disorders like autoimmune conditions, immunodeficiency disorders, cancer, and allergies. By introducing the immune system, our objective is to empower students to integrate their knowledge of cell biology into the understanding of immune regulation, fostering comprehension of this critical biological defense system.

Questions

1. How does the innate and adaptive immune system identify pathogens?
2. How were the B and T lymphocytes discovered?
3. Why is vaccination important, and what is the mechanism behind vaccination?
4. What is the process by which antigens trigger the production of high-affinity antibodies?

Readings, Websites or Video Clips

Chapter 1 of “Janeway’s Immunobiology” by Kenneth Murphy, Casey Weaver et.al, 9th edition

LEE Hsiang-Ying

Hsiang-Ying Lee, Ph.D., joined School of Life Sciences at Peking University and the Peking-Tsinghua Center for Life Sciences as an Assistant Professor and a Principal Investigator in 2017. Dr. Lee received her Ph.D. in Biomolecular Chemistry from University of Wisconsin-Madison, and conducted postdoctoral research at the Whitehead Institute for Biomedical Research/MIT. Dr. Lee’s research aims to understand how stem and progenitor cells integrate multiple environmental signals to make cell-fate decisions. She has published original studies in journals such as Nature, Nature Structural & Molecular Biology, Molecular Cell, Blood and PNAS. She was honored with the Outstanding Teaching Award for Graduate Students at Peking University, the Greenleaf Biomedicine Outstanding Young Scholar Award, the Bayer Investigator Award, the Yifang Young Scholar Award, and the Charles H. Hood (Charles A. King Trust) postdoctoral fellowship. The Lee laboratory’s research is centered on hematopoietic development, focusing on uncovering the mechanisms of chromatin dynamics and transcriptional regulation under normal and pathological conditions.

Course Title

Mathematical Modeling in the Life Sciences

生物数学建模

Instructor

TAO Louis / 陶乐天

Jackson Champer

First day of classes: 2024 / 02 / 21
Last day of classes: 2024 / 06 / 05
Course Code: 01139732
Course Credit: 3
Language: English

COURSE DESCRIPTION
课程简介

Objective

As modern life science research becomes ever more quantitative, the need for mathematical modeling becomes ever more important. A deeper and mechanistic understanding of complicated biological processes can only come from the understanding of complex interactions at many different scales, for instance, the molecular, the cellular, individual organisms and population levels.
In this course, through case studies, we will examine some simplified and idealized mathematical models and their underlying mathematical framework so that we learn how to construct simplified representations of complex biological processes and phenomena. We will learn how to analyze these models both qualitatively and quantitatively and interpret the results in a biological fashion by providing predictions and hypotheses that experimentalists may verify.

Pre-requisites / Target audience

Undergraduates; calculus and some familiarity with linear algebra

Evaluation Details

Problem Sets (PS) 50%, Project Presentation 5%, Final Project 45%

Text Books and Reading Materials

Dynamic Models in Biology, Stephen Ellner and John Guckenheimer, Princeton University Press (2006)

CLASS SCHEDULE
教学大纲

(Subject to adjustment)

Session 1
Introduction

Description of the Session
Introduction, Linear models [Reading: EG Chap. 1; Lab Manual 1-5]

Session 2
Linear Models

Description of the Session
Linear Models [Reading: EG Chap. 2; Lab Manual 6-9]

Session 3
Linear Models

Description of the Session
Linear Models

Session 4
Nonlinear Models

Description of the Session
Nonlinear Models

Session 5
Stochastics

Description of the Session
Stochastics [Reading: EG Chap. 3.1-3.3, Lab Manual 11]

Session 6
Stochastics

Description of the Session
Stochastics

Session 7
Introduction to Dynamical Systems

Description of the Session
Intro to Dynamical Systems & PS 2 due [Reading: EG Ch. 4, 5; Lab Manual 13-14]

Session 8
Introduction to Dynamical Systems

Description of the Session
Intro to Dynamical Systems

Session 9
The Hodgkin-Huxley Model

Description of the Session
Hodgkin-Huxley Neuronal Model & PS 3 due

Session 10
Hodgkin-Huxley Phase Plane Analysis

Description of the Session
Hodgkin-Huxley Dynamics & Phase Plane Analysis

Session 11
May Day (no class)

Description of the Session
May Day (no class)

Session 12
Excitable Systems

Description of the Session
Excitable Systems & PS 4 due

Session 13
Special Topics: Gene Drive

Description of the Session
Special Topics: Gene Drive

Session 14
Group Presentations

Description of the Session
Group Presentations

Session 15
Group Presentations

Description of the Session
Group Presentations

Session 16
Special Topics

Description of the Session
Special Topics

TAO Louis

Louis was transplanted from Taipei to New York at an early age and had dreams of becoming an astrophysicist. Later on, after two degrees (Harvard and the University of Chicago) and two postdocs in Physics (Cambridge and Columbia University), he found computational neuroscience to be his true calling. After moving to Peking University in 2008, he has worked on modeling primary visual cortex, theoretical aspects of neuronal population dynamics, information transfer and processing in neural circuits, neuromorphic computations, and live imaging of C. elegans behavior and its underlying neural circuits.

Jackson Champer

Jackson Champer was born in 1986 in New York City. He received a B.S. in physics and mathematics from the University of Oregon and a M.S. in physics from UCLA. Jackson then switched his focus to biology, receiving a Ph.D. from City of Hope Beckman Research Institute in 2015. He was a postdoctoral fellow at Cornell University with Philipp Messer and Andrew Clark from May 2016 until March 2021. Jackson opened his lab at Peking University in late May 2021. He currently studies gene drive, a process by which engineered alleles can spread throughout populations to prevent disease transmission in vector insects or to suppress populations of invasive species.

ENGLISH INSTRUCTED UNDERGRADUATE COURSES FOR SPRING 2024

2024年春季学期本科生英文授课课程目录

序号 NO.	课程号 Course Code	课程名称 Course Title	开课系所 Department/School	学分 Credit
1	00100890	代数选讲 Topics in Algebra	数学科学学院 School of Mathematical Sciences	3
2	00104128	量子理论 Quantum Theory	数学科学学院 School of Mathematical Sciences	3
3	00104143	模型论 Model theory	数学科学学院 School of Mathematical Sciences	3
4	00136710	随机过程与统计物理 Stochastic processes and statistical mechanics	数学科学学院 School of Mathematical Sciences	3
5	00333480	生物医学光学及应用 Biomedical Optics and Application	工学院 College of Engineering	3
6	00333630	细胞与分子影像学 Cellular and Molecular Imaging	工学院 College of Engineering	3
7	00405645	超快激光和光谱 Ultrafast Laser and Spectroscopy	物理学院 School of Physics	2
8	00432301	地球环境问题与应对 Earth's environmental problems and solutions	物理学院 School of Physics	2
9	00432510	固体物理学 Solid State Physics	物理学院 School of Physics	4
10	00434103	科学写作和交流 Introduction to Science Writing and Communication in English	物理学院 School of Physics	2
11	01034371	有机化学 (一) Organic Chemistry (I)	化学与分子工程学院 College of Chemistry and Molecular Engineering	3
12	01035180	定量分析化学 Quantitative Chemical Analysis	化学与分子工程学院 College of Chemistry and Molecular Engineering	2
13	01035200	物理化学（一） Physical Chemistry（I）	化学与分子工程学院 College of Chemistry and Molecular Engineering	3
14	01130150	细胞生物学 Cell Biology	生命科学学院 School of Life Sciences	3
15	01130200	遗传学 Genetics	生命科学学院 School of Life Sciences	3
16	01134101	生命科学前沿文献阅读讨论（1） Journal Club of the Frontier for Life Sciences(1)	生命科学学院 School of Life Sciences	2
17	01134102	生命科学前沿文献阅读讨论（2） Journal Club of the Frontier for Life Sciences(2)	生命科学学院 School of Life Sciences	2
18	01134103	生命科学前沿文献阅读讨论（3） Journal Club of the Frontier for Life Sciences(3)	生命科学学院 School of Life Sciences	2
19	01134104	生命科学前沿文献阅读讨论（4） Journal Club of the Frontier for Life Sciences(4)	生命科学学院 School of Life Sciences	2
20	01134105	生命科学前沿文献阅读讨论（5） Journal Club of the Frontier for Life Sciences(5)	生命科学学院 School of Life Sciences	2
21	01134106	生命科学前沿文献阅读讨论（6） Journal Club of the Frontier for Life Sciences(6)	生命科学学院 School of Life Sciences	2
22	01134107	生命科学前沿文献阅读讨论（7） Journal Club of the Frontier for Life Sciences(7)	生命科学学院 School of Life Sciences	2
23	01137013	学习记忆的神经基础 Learning and memory in the brain	生命科学学院 School of Life Sciences	2
24	01138540	分子生物学 Molecular Biology	生命科学学院 School of Life Sciences	3
25	01139630	生物化学 Biochemistry	生命科学学院 School of Life Sciences	4

序号 NO.	课程号 Course Code	课程名称 Course Title	开课系所 Department/School	学分 Credit
26	01139732	生物数学建模 Mathematical Modeling in the Life Sciences	生命科学学院 School of Life Sciences	3
27	01139916	人工智能与衰老再生的系统生物学 AI and Systems Biology of Aging and Rejuvenation	生命科学学院 School of Life Sciences	3
28	01231710	层序地层学基础 Elementary Sequence Stratigraphy	地球与空间科学学院 School of Earth and Space Sciences	2
29	01231820	地球生物学概论 Principles of Geobiology	地球与空间科学学院 School of Earth and Space Sciences	2
30	01231860	海洋环境和动力学 Marine Environments and Geodynamics	地球与空间科学学院 School of Earth and Space Sciences	2
31	01231882	地球系统演化 The Earth System Evolution	地球与空间科学学院 School of Earth and Space Sciences	3
32	01233640	地球物理学术论文写作 Writing Scientific Articles in Geophysics	地球与空间科学学院 School of Earth and Space Sciences	2
33	01630073	记忆的神经生物学机制 Neurobiology of memory	心理与认知科学学院 School of Psychological and Cognitive Sciences	2
34	01630350	教育心理学 Educational Psychology	心理与认知科学学院 School of Psychological and Cognitive Sciences	2
35	01630735	生理学 Physiology	心理与认知科学学院 School of Psychological and Cognitive Sciences	2
36	01834346	国际新闻实践与案例 Case Study and Practice of International Journalism	新闻与传播学院 School of Journalism & Communication	2
37	02113124	拉丁语阅读 (4) Intermediate Latin 4	历史学系 School of History	2
38	02132630	法国史 History of France	历史学系 School of History	2

序号 NO.	课程号 Course Code	课程名称 Course Title	开课系所 Department/School	学分 Credit
39	02133103	基督教拉丁语 (3) Ecclesiastical Latin	历史学系 School of History	2
40	02133162	基础拉丁语（2） Elementary Latin 2	历史学系 School of History	2
41	02133682	外文历史史料选读（下） Readings on Historical Sources in English (2)	历史学系 School of History	2
42	02139080	罗马史 History of Rome	历史学系 School of History	2
43	02313740	哲学研讨会 Philosophy Workshop	哲学系 Department of Philosophy and Religious Studies	3
44	02319642	传统太极拳：哲学与实践 Traditional Taijiquan: Different Philosophy & Practice	哲学系 Department of Philosophy and Religious Studies	2
45	02330001	哲学导论 An Introduction to Philosophy	哲学系 Department of Philosophy and Religious Studies	2
46	02330003	哲学导论 Introduction to Philosophy	哲学系 Department of Philosophy and Religious Studies	3
47	02432090	本土视野下的中国外交与国际事务 Chinese Perspective on International and Global Affairs	国际关系学院 School of International Studies	3
48	02432110	国际安全研究 International Security Studies	国际关系学院 School of International Studies	3
49	02432140	中国政治与公共政策 Chinese Politics and Public Policy	国际关系学院 School of International Studies	3
50	02432429	中国与国际法 China and International Law	国际关系学院 School of International Studies	3
51	02500250	可持续发展与经济政策 Sustainable Development and Economic Policy	经济学院 School of Economics	2
52	02530060	微观经济学 Microeconomics	经济学院 School of Economics	3
53	02533290	保险公司运作与管理 Insurance Operation	经济学院 School of Economics	2

序号 NO.	课程号 Course Code	课程名称 Course Title	开课系所 Department/School	学分 Credit
54	02533461	开放经济的货币金融政策 Monetary and Financial Policy in Open Economies	经济学院 School of Economics	2
55	02533570	公司金融 Corporate Finance	经济学院 School of Economics	3
56	02533600	产业组织理 论 Theory of Industrial Organization	经济学院 School of Economics	3
57	02534090	专业英语 English for Economics Majors	经济学院 School of Economics	2
58	02534270	经济地理学 Economic Geography	经济学院 School of Economics	2
59	02534280	卫生经济学 Health Economics	经济学院 School of Economics	2
60	02535030	企业全面风险管理 Enterprise Risk Management	经济学院 School of Economics	2
61	02535250	外国经济史 World Economic History	经济学院 School of Economics	3
62	02535320	应用时间序列分析 Applied Time Series Analysis	经济学院 School of Economics	2
63	02535360	人寿与健康保险 Life and Health Insurance	经济学院 School of Economics	2
64	02813050	大数据与资本市场研究 Big Data and Captial Market Research	光华管理学院 Guanghua School of Management	2
65	02830240	运营管理 Operations Management	光华管理学院 Guanghua School of Management	2
66	02830260	影子中央银行 Shadow PBoC	光华管理学院 Guanghua School of Management	2
67	02831520	会计学 Accounting	光华管理学院 Guanghua School of Management	3
68	02833230	金融市场与金融机构 Financial Markets and Financial Institutions	光华管理学院 Guanghua School of Management	3

序号 NO.	课程号 Course Code	课程名称 Course Title	开课系所 Department/School	学分 Credit
69	02837020	投资银行 Investment Banking	光华管理学院 Guanghua School of Management	2
70	02837170	策略与博弈 Game Theory	光华管理学院 Guanghua School of Management	3
71	02838130	中国社会与商业文化 Chinese Society and Business Culture	光华管理学院 Guanghua School of Management	2
72	02838950	社会影响力营销 Marketing for Social Impact	光华管理学院 Guanghua School of Management	2
73	02839080	中国金融 Finance in China	光华管理学院 Guanghua School of Management	2
74	02839200	人工智能和社会经济 AI and Economics	光华管理学院 Guanghua School of Management	2
75	02839580	创新创业经济学 Economics of Entrepreneurship and Innovation	光华管理学院 Guanghua School of Management	3
76	02839590	组织经济学 Organizational Economics	光华管理学院 Guanghua School of Management	2
77	03033970	数据叙事：描述、分析与叙述 Data Storytelling: Descriptions, Analytics, and Narratives	信息管理系 Department of Information Management	2
78	04430004	当代中国 Introduction to Contemporary China	对外汉语教育学院 School of Chinese as a Second Language	2
79	04832710	自然语言处理中的经验性方法 Empirical Methods in Natural Language Processing	信息科学技术学院 School of Electronics Engineering and Computer Science	3
80	06232000	经济学原理 Principles of Economics	国家发展研究院 National School of Development	4
81	06238090	经济增长导论 Introduction to Economic Growth	国家发展研究院 National School of Development	3

序号 NO.	课程号 Course Code	课程名称 Course Title	开课系所 Department/School	学分 Credit
82	06239073	管理学经典选读 Classics in Management	国家发展研究院 National School of Development	3
83	06239085	中级微观经济学 Intermediate Microeconomics	国家发展研究院 National School of Development	3
84	06239098	国际贸易 International Trade	国家发展研究院 National School of Development	3
85	06239136	经济学高级研讨班 Advanced Research Seminar	国家发展研究院 National School of Development	3
86	06239141	公共政策参与 Public Policy Engagement	国家发展研究院 National School of Development	3
87	12730020	变化中的地球 Our Changing Planet	环境科学与工程学院 College of Environmental Sciences and Engineering	2
88	23200007	材料科学与工程专业英语 Professional English of Materials Science and Engineering	材料科学与工程学院 School of Materials Science and Engineering	2
89	E2800010	跨文化沟通 Cross-Cultural Communication	光华管理学院 Guanghua School of Management	2
90	E2800040	组织行为与领导力 Organization Behavior and Leadership	光华管理学院 Guanghua School of Management	3
91	E2800100	中国管理（二） Chinese Management 2	光华管理学院 Guanghua School of Management	2
92	E2800120	企业伦理与社会责任 Business Ethics and CSR	光华管理学院 Guanghua School of Management	2
93	E2800160	国际经济 International Economics	光华管理学院 Guanghua School of Management	2
94	E2800220	投资中国 Investing in China	光华管理学院 Guanghua School of Management	2
95	E2800230	营销管理 Marketing Management	光华管理学院 Guanghua School of Management	2

序号 NO.	课程号 Course Code	课程名称 Course Title	开课系所 Department/School	学分 Credit
96	E2800270	创新理论与实践 Theory and Practice of Innovation	光华管理学院 Guanghua School of Management	2
97	E2800290	财务会计应用 Financial Accounting Application	光华管理学院 Guanghua School of Management	2
98	E2834421	证券投资学 Security Analysis and Investment	光华管理学院 Guanghua School of Management	3
99	E4030002	西方马克思主义思想中的当代批判理论 Contemporary Critical Theory in Western Marxian Thought	马克思主义学院 School of Marxism	1

For more information, please refer to *https://dean.pku.edu.cn/service/web/courseSearchEn.php*

备注：以上目录中课程仅供参考，是否可选根据开课实际情况确定。
Note: The Courses in the above catalogue are for reference only. Whether they can be selected depends on the actual situation of the course.

https://dean.pku.edu.cn/service/web/courseSearchEn.php