北京大学
PEKING UNIVERSITY

GLOBAL OPEN COURSES

全球课堂

2025 Spring

北京大学教务部
Office of Educational Administration

北京大学国际合作部
Office of International Relations

北京大学教务长办公室
Office of Provost

北京大学教师教学发展中心
Center for Excellent Teaching and Learning

目录

CATALOGUE

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。

2025 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 2025, 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.

COURSE SCHEDULE

All times are Beijing time

Course name	Course time (Beijing time)	Language	Instructor
Earth's Environmental Problems and Solutions 地球环境问题与应对	Tuesday 13:00–14:50	English	Mikinori Kuwata
Solid State Physics 固体物理学	Monday 13:00–14:50 Wednesday 10:10–12:00	English	Jianhao Chen; Xiongjun Liu
Ultrafast Laser and Spectroscopy 超快激光和光谱	Friday 10:10–12:00	English	Kebin Shi
Biochemistry 生物化学	Tuesday 18:40–20:30 Thursday 15:10–17:00	English	Junyu Xiao; Xiaowei Chen; Chengqi Yi
Genetics 遗传学	Monday 15:10–17:00 (biweekly 单周) Wednesday 15:10–17:00	English	Yan Song; Jian Lu
Cell Biology 细胞生物学	Monday 18:40–20:30 (biweekly 单周) Thursday 18:40–20:30	English	Hsiang-Ying Lee; Xiaowei Chen; Guoqiang Li; Ying Zhang; Yuezhou Chen
Mathematical Modeling in the Life Sciences 生物数学建模	Wednesday 18:40–21:30	English	Louis Tao; Jackson Champer
Molecular Biology 分子生物学	Monday 15:10–17:00 (biweekly 双周) Thursday 15:10–17:00	English	Qing Li; Wensheng Wei
Frontiers of Materials Science and Engineering 材料科学与工程专业英语	Monday 18:40–20:30	English	Xiaoxu Zhao

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

Course Title

Earth's Environmental Problems and Solutions

地球环境问题与应对

Instructor

Mikinori Kuwata

First day of classes：February 18, 2025
Last day of classes：June 3, 2025
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

No special requirement

Target audience/All undergraduate students in all disciplines. Students who 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 (If necessary)

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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

Lecture

Purpose

After the lecture, students will be able to 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(purpose, requirements, class and presentations scheduling, etc.)
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(purpose, requirements, class and presentations scheduling, etc.)
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(purpose, requirements, class and presentations scheduling, etc.)
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(purpose, requirements, class and presentations scheduling, etc.)
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

Description of the Session (purpose, requirements, class and presentations scheduling, etc.)
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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

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

About the instructor

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

Jian-Hao Chen 陈剑豪
Xiongjun Liu 刘雄军

First day of classes：February 17, 2025
Last day of classes：June 4, 2025
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)

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

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)

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

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)

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

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)

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

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)

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

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)

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

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.

About the instructor

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.

About the instructor

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

Kebin Shi 施可彬

First day of classes：February 21, 2025
Last day of classes：June 6, 2025
Course NO.：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(purpose, requirements, class and presentations scheduling, etc.)

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

Session 2
Fundamental concepts II

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

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

Session 3
Fundamental concepts III

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

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

Session 4
Propagation law I

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Propagation of ultrafast laser pulse I

Session 5
Propagation law II

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Propagation of ultrafast laser pulse II

Session 6
Dispersion: a time domain analogy of diffraction

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Phase modulation in ultrafast optics: dispersion and diffraction

Session 7
Optical devices in ultrafast optics I

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

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

Session 8
Optical devices in ultrafast optics II

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

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

Session 9
Optical devices in ultrafast optics III

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

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

Session 10
Mode locking mechanism I

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Theory and design of mode-locking laser I

Session 11
Mode locking mechanism II

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Theory and design of mode-locking laser II

Session 12
Laser pulse measurements I

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Characterization techniques for ultrafast laser pulse I

Session 13
Laser pulse measurements II

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Characterization techniques for ultrafast laser pulse II

Session 14
Nonlinear interactions in ultrafast optics

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Introduction to ultrafast-nonlinear optics

Session 15
Applications I

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Ultrafast laser spectroscopy technologies: time resolved framework, pump-probe technique, THz techniques

Session 16
Applications II

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Optical imaging technologies based on ultrafast optics

About the instructor

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

Junyu Xiao 肖俊宇
Xiaowei Chen 陈晓伟
Chengqi Yi 伊成器

First day of classes：February 18, 2025
Last day of classes：June 5, 2025
Course NO.：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

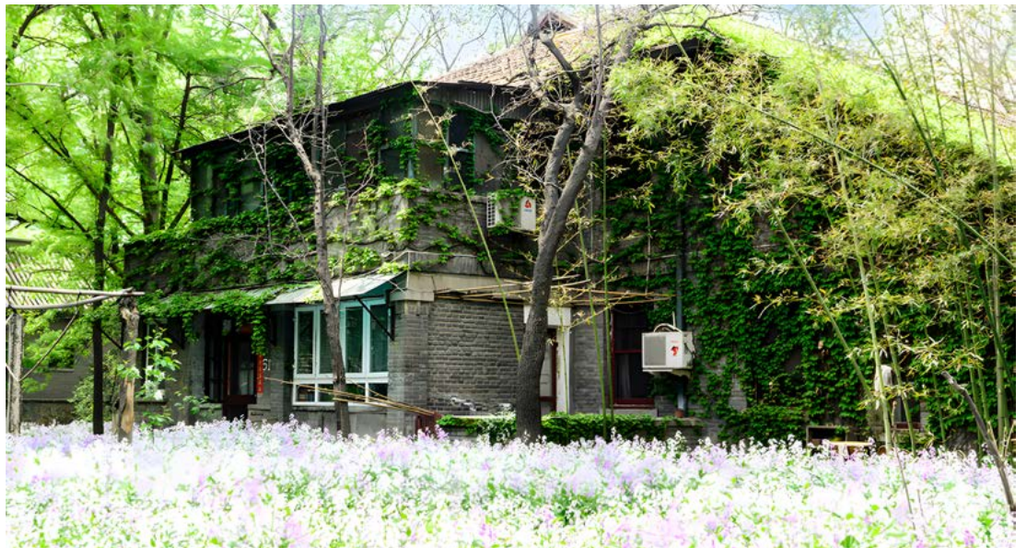
About the instructor

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.

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.

About the instructor

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
Yan Song 宋艳
Jian Lu 陆剑

First day of classes：February 17, 2025
Last day of classes：June 4, 2025
Course NO.：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: Genetics: from Genes to Genomes (the sixth edition)

CLASS SCHEDULE
教学大纲

Subject to adjustment

Teaching Faculty & Reference Book

Yan Song 宋艳

Jian Lu 陆剑

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

Syllabus

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
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

About the instructor

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.

About the instructor

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
Hsiang-Ying Lee 李湘盈
Xiaowei Chen 陈晓伟
Guoqiang Li 李国强
Ying Zhang 张莹
Yuezhou Chen 陈玥舟

First day of classes：February 17, 2025
Last day of classes：June 5, 2025
Course NO.：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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

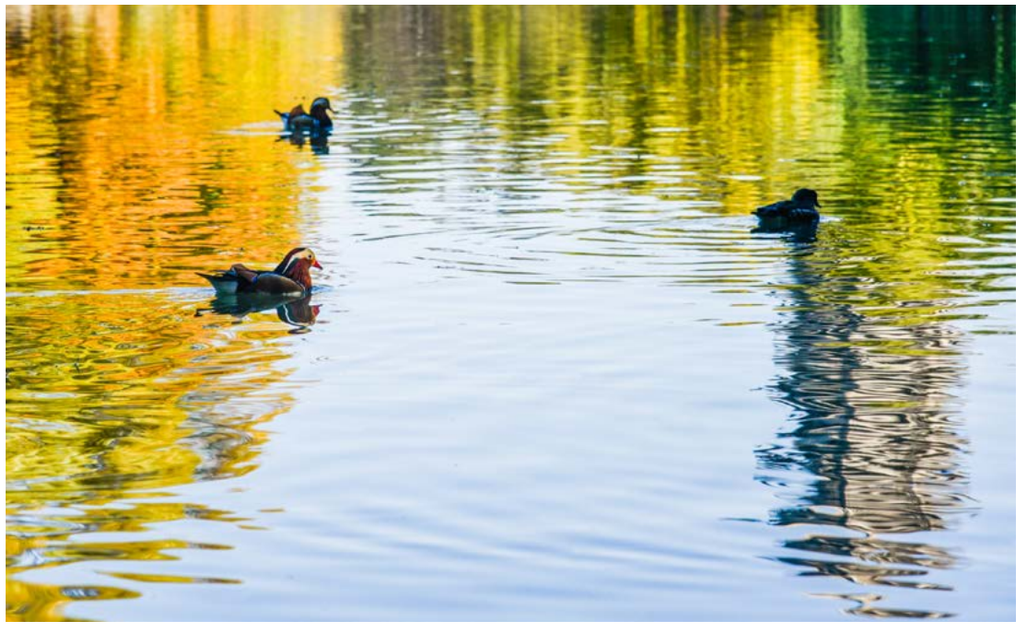
This class would cover the cellular mechanisms that direct proteins to their proper destinations within or outside the cell. It will explore the sorting signals that determine protein destinations, the vesicular transport systems, and the molecular machinery involved in the fusion and fission of transport 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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

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.

2. What are the regulatory mechanisms that control the rearrangement of cell–cell junctions in epithelia during early development?

Questions

1. What are the major differences in cell connections between connective tissues and epithelial tissues?

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(purpose, requirements, class and presentations scheduling, etc.)

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(purpose, requirements, class and presentations scheduling, etc.)

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 utilize 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(purpose, requirements, class and presentations scheduling, etc.)

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

About the instructor

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

Louis Tao 陶乐天

Jackson Champer

First day of classes：February 19, 2025

Last day of classes：June 4, 2025

Course NO.：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

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

Session 2
Linear Models

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

Session 3
Linear Models

Linear Models

Session 4
Nonlinear Models

Nonlinear Models

Session 5
Stochastics

Stochastic Models [Reading: EG Chap. 3.1-3.3, Lab Manual 11]

Session 6
Stochastics

Stochastic Models

Session 7
Introduction to Dynamical Systems

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

Session 8
Introduction to Dynamical Systems

Intro to Dynamical Systems

Session 9
The Hodgkin-Huxley Model

Hodgkin-Huxley Neuronal Model & PS 3 due

Session 10
Hodgkin-Huxley Phase Plane Analysis

Hodgkin-Huxley Dynamics & Phase Plane Analysis

Session 11
Excitable Systems

Excitable Systems

Session 12
May Break

No class

Session 13
Special Topics: Gene Drive

Special Topics: Gene Drive & PS 4 due

Session 14
Group Presentations

Group Presentations

Session 15
Group Presentations

Group Presentations

Session 16
Special Topics

Special Topics

About the instructor

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 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.

Course Title

Molecular Biology

分子生物学

Instructor

Qing Li 李晴：Lectures 1-12

Wensheng Wei 魏文胜：Lectures 13-24

First day of classes：February 20, 2025
Last day of classes：June 5, 2025
Course NO.：01138540
Course Credit：3
Language：English

COURSE DESCRIPTION
课程简介

Objective

This course delves into foundational concepts and recent advances in molecular biology, equipping students with a rigorous understanding of the structures, functions, and regulatory mechanisms of biological macromolecules. Through a systematic approach, it covers essential pathways from DNA to protein synthesis, including the central dogma and its multifaceted regulatory processes, as well as key experimental techniques in molecular biology. Students will acquire in-depth theoretical knowledge on DNA replication, repair, transcription, translation, and gene regulation, along with applications in biotechnology, gene editing, and human health. Emphasizing the integration of theory with experimental practice, the course aims to cultivate critical thinking, analytical problem-solving, and scientific literacy, establishing a robust foundation for careers in research, clinical sciences, and bioengineering

Pre-requisites /Target audience

This course is suitable for all students with an interest in molecular biology, particularly those majoring in fields such as biological sciences, biotechnology, biomedicine, and related disciplines. No specific prerequisites are required.

Proceeding of the Course

The course will be conducted through lectures, video demonstrations, and group discussions, mainly covering the following topics:

- History of Molecular Biology
- Maintenance of the genome
- Expression of the genome
- Regulation
- Techniques of molecular biology

Assignments (essay or other forms)

There will be the mid-term and final exams, as well as two term papers.

Evaluation Details

Mid-term Exam(40%), Final Exam(40%), and two term-papers (10% each)

Text Books and Reading Materials

Text Book:
Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013)
References:
Molecular Biology of the Cell, 7th Edition (Alberts Johnson, Lewis Raff, Roberts Walter)
Genes XII (Benjamin Lewin)
现代分子生物学，第五版 (朱玉贤，李毅，郑晓峰，郭红卫)

Academic Integrity (If necessary)

Students must adhere to the principles of academic integrity and refrain from plagiarism, copying others' work, or cheating. Any academic misconduct will be dealt with seriously.

CLASS SCHEDULE
教学大纲

Subject to adjustment

Session 1
History of Molecular Biology

Date:2/20/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Purpose: Introducing the foundational concepts of molecular biology and tracing its historical development.
Requirements: Pre-read relevant textbook materials, attentively listen to lectures, and actively participate in discussions.
Class and Presentations Scheduling: The session will include lectures on the Birth of Molecular Biology, The Central Dogma, and Technology Development.

Questions

What are the key milestones in the development of molecular biology?
How does the Central Dogma govern the flow of genetic information?
What technological innovations have revolutionized molecular biology?
What insights can we gain from historical perspectives on molecular biology?

Readings, Websites or Video Clips

Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013) Pages 21-30; 77-104; 147-158.

Assignments for this session (if any)

None

Session 2:
The Structure of DNA & Technique I

Date:2/24/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Purpose: This session is to equip students with a solid foundation in molecular biology, particularly focusing on DNA-related concepts. By the end of the session, students should have a clear understanding of DNA/RNA structure, DNA topology, and basic molecular biology techniques.
Requirements: Pre-read relevant textbook materials, attentively listen to lectures, and actively participate in discussions.
Class and Presentations Scheduling: The session will include lectures on the structure of DNA, techniques of molecular biology, the chemistry of DNA synthesis and the mechanism of DNA polymerase.

Questions

What are the fundamental components of DNA structure, and how do they contribute to its functionality?
What is DNA topology? How does DNA topology impact DNA transactions?
What are the basic techniques used in molecular biology, and how are they applied to studying DNA?

Readings, Websites or Video Clips

Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013) Pages 77-104; 147-191; 257-269.

Assignments for this session (if any)

None

Session 3
The Chemistry of DNA Synthesis

Date:2/27/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Purpose: This session provides students with a comprehensive understanding of the biochemical processes involved in DNA synthesis and replication. Through an exploration of DNA synthesis chemistry, the mechanisms of DNA polymerase, and the stages of replication, students will build a solid foundation in molecular biology, essential for advanced studies and applications.
Requirements: Students are expected to have a basic understanding of biochemistry and molecular biology concepts. It is recommended that prerequisite courses in introductory biology and chemistry be completed to fully engage with the session content.
Class and Presentations Scheduling: The session will include lectures on the chemistry of DNA synthesis, the mechanism of DNA polymerase, and the replication in the cell.

Questions

What are the key chemical processes involved in DNA synthesis?
How does DNA polymerase function in the replication process?

What are the stages of DNA replication in the cell?
How do the initiation, elongation, and termination stages of replication differ in their molecular mechanisms?

Readings, Websites or Video Clips
Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013) Pages 257-311.

Assignments for this session (if any)
None

Session 4
DNA Replication Fork

Date:3/6/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)
Purpose: This session aims to deepen participants' understanding of the structure of the DNA replication fork, the replisome, and the functions of the protein machinery involved in replication, as well as their coordination. The DNA replication fork is a dynamic and complex structure that requires the coordinated action of numerous enzymes and regulatory factors to ensure accurate and efficient DNA replication, while also preserving genomic stability and epigenetic information.
Requirements: Students are expected to have a solid understanding of basic molecular biology concepts, including DNA structure, replication, and gene expression. Prior coursework in molecular biology or related fields is recommended.
Class and Presentations Scheduling: Pre-read relevant textbook materials, attentively listen to lectures, and actively participate in discussions.

Questions
How is the DNA replication fork structured and coordinated to ensure accurate and efficient DNA replication? What are the key components of the replication fork? How are the leading and lagging strands synthesized? What are the dynamics of the replisome? What role do chromatin and epigenetic information play in replication fork dynamics? Understanding these key questions is essential for grasping the complexity and precision involved in the DNA replication fork and its role in maintaining genome integrity.

Readings, Websites or Video Clips
Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013) Pages 269-311.

Assignments for this session (if any)
None

Session 5
The Replication of DNA in Cells

Date:3/10/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)
Purpose: This session is to deepen participants' knowledge and understanding of DNA replication processes, from the initiation to the completion stage. By the end of the session, participants should have a clear grasp of the molecular events and mechanisms involved in DNA replication, as well as the differences between prokaryotic and eukaryotic replication processes.
Requirements: Students are expected to have a solid understanding of basic molecular biology concepts, including DNA structure, replication, and gene expression. Prior coursework in molecular biology or related fields is recommended.
Class and Presentations Scheduling: Pre-read relevant textbook materials, attentively listen to lectures, and actively participate in discussions.

Questions
How is DNA replication initiated in cells? Similarities between Eukaryotic and

prokaryotic DNA replication initiation? What are the mechanisms to ensure eukaryotic chromosomes replicate exactly once per cell cycle? What are the mechanisms for finishing DNA replication?

Readings, Websites or Video Clips
Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013) Pages 199-255

Assignments for this session (if any)
None

Session 6
Genome Structure, Chromatin, and the Nucleosome

Date: 3/13/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)
Purpose: This session aims to provide a comprehensive understanding of genome sequences and chromosome diversity, the process of chromosome duplication and segregation, the structure and function of nucleosomes, higher-order chromatin organization, and the regulation of chromatin structure. Additionally, an introduction to the field of epigenetics will be covered, highlighting its significance in gene expression and inheritance.
Requirements: Students should have a basic understanding of molecular biology and genetics. Preparation includes reviewing molecular biology concepts and completing assigned readings.

Questions
What are the key differences between prokaryotic and eukaryotic chromosome structures?
How do nucleosomes contribute to higher-order chromatin structure?
What mechanisms ensure accurate chromosome duplication and segregation during cell division?

Readings, Websites or Video Clips
Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013) Chapter 8, Pages 199-255

Assignments for this session (if any)
None

Session 7
Chromatin Structure and Epigenetic Regulation

Date: 3/20/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)
Purpose: The purpose of this lesson is to explore the regulation of chromatin structure and introduce the concept of epigenetics. Chromatin structure plays a pivotal role in gene expression regulation by determining accessibility to DNA. Understanding its regulation provides insights into how cells control gene activity through epigenetic mechanisms, influencing development, differentiation, and disease processes.
Requirements: In this lesson, students are required to comprehend the principles underlying chromatin structure regulation, including histone modifications, DNA methylation, and chromatin remodeling complexes. They should analyze how these epigenetic mechanisms influence gene expression patterns and cellular phenotypes.

Questions
How does epigenetic regulation affect gene expression and chromatin structure?
How does higher-order chromatin structure affect gene expression? How do errors in chromosome duplication and segregation affect cellular function?
What mechanisms ensure accurate chromosome segregation?
What epigenetic modification mechanisms influence chromatin structure?

Readings, Websites or Video Clips
Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013) Chapter 8, Pages 199-255

Assignments for this session (if any)
None

Session 8
DNA Repair

Date:3/24/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)
Purpose: This course aims to provide a detailed understanding of DNA replication errors, the molecular mechanisms that cause these errors, and the various cellular processes involved in repairing DNA damage. By exploring these topics, students will gain insights into how cells maintain genetic stability and prevent diseases such as cancer.
Requirements: To complete this course, students must acquire theoretical knowledge of DNA replication, damage,

and repair, develop practical skills in identifying and studying these processes, and critically analyze scientific literature.

Questions

What are the main types of DNA replication errors, and how are they generated?
What are the sources and types of DNA damage? What are their effects on cellular function?
How do cells recognize and repair DNA replication errors?
What are the key molecular mechanisms involved in DNA repair processes?
What are the differences in efficiency and accuracy among various DNA repair pathways? Why are certain repair pathways preferred under specific conditions?

Readings, Websites or Video Clips

Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013) Pages 313-338

Assignments for this session (if any)

None

Session 9
Homologues Recombination at the Molecular Level

Date: 3/27/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Purpose: This course aims to explore the molecular mechanisms underlying homologous recombination, focusing on the protein machinery involved and its role in genetic processes such as mating-type switching. Through detailed examination, students will gain insights into how these mechanisms contribute to genetic diversity and stability in organisms.
Requirements: Students are expected to demonstrate a comprehensive understanding of models and proteins involved in homologous recombination, as well as the implications of these processes on genetic variation and stability.

Questions

What are the key proteins involved in homologous recombination, and how do they facilitate the exchange of genetic material between homologous chromosomes?
What are the differences between homologous recombination and other mechanisms of DNA repair, such as non-homologous end joining (NHEJ)?

Readings, Websites or Video Clips

Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013) Pages 341-376

Assignments for this session (if any)

None

Session 10
Site-Specific Recombination

Date: 4/4/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Purpose: The purpose of this lesson is to explore the mechanisms and biological significance of site-specific recombination and transposition in genetic processes. Specifically, we aim to understand how these molecular events contribute to genetic diversity, regulatory control of gene expression, and genome evolution in various organisms.
Requirements: In this lesson, students are required to grasp the fundamental principles underlying conservative site-specific recombination and transposition. They should be able to describe the mechanisms involved in these processes, discuss their biological roles such as in regulation of gene expression and adaptation, and analyze specific examples of their occurrence in both prokaryotic and eukaryotic genomes.

Questions

How does site-specific recombination contribute to the regulation of gene expression in prokaryotes and eukaryotes?
What are the similarities and differences between conservative site-specific recombination and transposition in terms of their molecular mechanisms and biological outcomes?
What are the evolutionary advantages and potential disadvantages of transposable elements (TEs) in shaping genome architecture and promoting genetic diversity?

Readings, Websites or Video Clips

Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013) Pages 377-420

Assignments for this session (if any)

None

Session 11
Transposable Elements

Date: 4/7/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Purpose: The purpose of this lesson is to delve into the biology of transposable elements (TEs) and their regulation within genomes. TEs are genetic entities capable of moving within and between genomes, impacting genome structure, evolution, and gene regulation. Understanding their mechanisms of regulation is crucial for comprehending how organisms maintain genomic stability while harnessing the potential benefits of TEs.

Requirements: In this lesson, students are required to explore the diversity and classification of transposable elements, including their mechanisms of transposition and the factors influencing their regulation. They should analyze the biological significance of TEs in genome evolution, gene expression regulation, and adaptation processes.

Questions

How do organisms balance the beneficial contributions versus the potentially harmful effects of transposable elements (TEs) in maintaining genomic stability and evolutionary flexibility?

What are the molecular mechanisms involved in the regulation of transposable elements (TEs), including epigenetic modifications, small RNA pathways, and other cellular mechanisms?

How do transposable elements (TEs) influence the evolution of host genomes, including their role in genetic diversity, adaptation to environmental changes, and speciation events?

Readings, Websites or Video Clips

Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013) Pages 377-420

Assignments for this session (if any)

None

Session 12
Mechanisms of Transcription

Date:4/21/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Purpose: This session covers the mechanisms of transcription, focusing on the central dogma processes, which involve transcription, translation, and replication. Specifically, it explores how DNA is transcribed into RNA, the stages involved, and the differences between prokaryotic and eukaryotic transcription.

Requirements: The lecture material outlines fundamental concepts in molecular biology for understanding transcription processes. It also dives into the role of different RNA polymerases and factors in both prokaryotes and eukaryotes.

Questions

What are the key differences between transcription and DNA replication?

How do eukaryotic RNA polymerases differ in their functions?

What roles do general transcription factors play in eukaryotic transcription initiation?

How does Rho-dependent termination differ from Rho-independent termination in bacteria?

What is the function of the CTD in RNA Polymerase II during transcription?

Readings, Websites or Video Clips

Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013) Pages 429-466

Assignments for this session (if any)

None

Session 13
RNA Splicing

Date:4/24/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Purpose: The session focuses on advanced aspects of transcription in eukaryotes and introduces RNA splicing mechanisms. It details how transcription is regulated, the roles of specific proteins and complexes in transcription and RNA processing, and the intricate steps of spliceosome-mediated splicing.

Requirements: This session builds on basic transcription knowledge, requiring familiarity with RNA polymerase II and associated general transcription factors (GTFs). It also requires an understanding of molecular biology basics to follow the transcription cycle, RNA processing, and the spliceosome's function.

Questions

How does the spliceosome facilitate RNA splicing?

What mechanisms ensure the accuracy of splice site selection during RNA processing?

Readings, Websites or Video Clips

Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013) Pages 467-508

Assignments for this session (if any)

None

Session 14
RNA Splicing

Date:5/5/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Purpose: This session delves deeper into RNA splicing, covering advanced mechanisms and variations, including alternative splicing, exon shuffling, and RNA editing. It explores how these processes contribute to protein diversity, gene regulation, and evolutionary adaptations.

Requirements: Students need a foundational understanding of molecular biology, specifically transcription and translation, to grasp RNA splicing pathways. Familiarity with splicing machinery, including snRNPs and spliceosomes, is essential.

Questions

What are the main steps in the spliceosome-mediated splicing reaction?

How does the spliceosome accurately recognize splice sites?

What is the role of SR proteins in RNA splicing?

How does alternative splicing contribute to protein diversity?

What mechanisms are involved in nonsense-mediated decay?

How does exon shuffling contribute to the evolution of new proteins?

What processes are involved in RNA editing, and how do they alter mRNA sequences?

Readings, Websites or Video Clips

Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013) Pages 467-508

Assignments for this session (if any)

None

Session 15
Translation

Date:5/9/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Purpose: Outlines the translation process, detailing the components involved, such as mRNAs, tRNAs, aminoacyl-tRNA synthetases, and ribosomes. To explore the translation process: initiation, elongation, and termination. Special mechanisms, such as Internal Ribosome Entry Sites (IRES), allow for cap-independent translation initiation, highlighting the complexity and regulation of protein synthesis.

Requirements: Understanding of basic molecular biology concepts like transcription, translation, and replication. Familiarity with the central dogma of molecular biology.

Questions

What are the main differences in translation mechanisms between prokaryotes and eukaryotes?

How do initiation factors in prokaryotic translation differ from those in eukaryotic translation?

Readings, Websites or Video Clips

Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013) Pages 509-572

Assignments for this session (if any)

None

Session 16
Regulation of Translation

Date:5/12/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Purpose: Discuss translation processes and regulatory mechanisms, including tRNA charging, ribosome function, translation initiation, elongation, and termination. Explore regulation of translation in both bacteria and eukaryotes.

Requirements: Basic molecular biology knowledge, especially related to translation and tRNA. Understanding of different stages of translation and their molecular mechanisms.

Questions

What are the specific steps involved in tRNA charging?

How does the ribosome ensure correct amino acid pairing during translation?

What are the differences in initiation factors between bacterial and eukaryotic translation?

How do 4E-BPs affect eIF4E in the regulation of translation?

How does nonsense-mediated decay recognize and degrade mRNAs with premature stop codons?

Readings, Websites or Video Clips

Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013) Pages 509-572

Assignments for this session (if any)

None

Session 17
The Genetic Code

Date:5/15/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Purpose: To explore the mechanisms of translation termination, the genetic code, and transcriptional regulation. Discusses the roles of release factors in translation, the degeneracy and wobble of the genetic code, and principles of transcriptional regulation.

Requirements: Understanding of molecular biology concepts, particularly translation and transcription. Familiarity with genetic code properties and regulatory mechanisms.

Questions

How do release factors recognize stop codons and terminate translation?

What is the significance of wobble pairing in the genetic code?

How do activators and repressors function in transcriptional regulation?

What mechanisms are involved in nonsense-mediated mRNA decay?

How does the lac operon demonstrate transcriptional regulation in prokaryotes?

Readings, Websites or Video Clips

Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013) Pages 573-592

Assignments for this session (if any)

None

Session 18
transcriptional regulation

Date:5/19/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Purpose: The purpose of this class is to explore the mechanisms of translational regulation and understand how cells control protein synthesis in response to various signals. By the end of the course, students will be able to describe the different regulatory steps involved in translation, the role of translation factors, and how translational control can influence cellular processes.

Requirements: Basic knowledge of molecular biology, including transcription, translation, and gene expression Class and Presentations Scheduling: Pre-read relevant textbook materials, attentively listen to lectures, and actively participate in discussions.

Session 19
Transcriptional regulation II

Date:5/22/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Purpose: The purpose of this class is to explore the mechanisms of transcriptional regulation, focusing on both prokaryotic and eukaryotic systems. By the end of the course, students will understand how activators, repressors, and other regulatory elements control gene expression, as well as the role of chromatin structure and transcriptional machinery in modulating gene activity

Requirements: Basic knowledge of molecular biology, including DNA, RNA, and gene expression. Familiarity with transcriptional processes, including RNA polymerase and transcription factors. Willingness to engage in discussions on transcriptional control mechanisms. Participation in group activities and presentations on specific transcriptional regulatory systems. Class and Presentations Scheduling: Pre-read relevant textbook materials, attentively listen to lectures, and actively participate in discussions.

Questions
What are the differences between transcriptional regulation in prokaryotes and eukaryotes?
How do nucleosome modifications influence transcription, and why is this important in eukaryotic regulation?
What role do enhancers play in gene regulation, and how do insulators prevent unwanted gene activation?
How does the lac operon serve as a model for understanding transcriptional regulation in prokaryotes?
What are some examples of combinatorial control in eukaryotic transcription, and how do they contribute to gene regulation complexity?

Readings, Websites or Video Clips
Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013)

Assignments for this session (if any)
None

Session 20
Transcriptional regulation III Regulatory RNA

Date: 5/29/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)
Purpose: The purpose of this class is to explore the mechanisms of transcriptional regulation by regulatory RNAs, focusing on how small RNAs control gene expression in both prokaryotic and eukaryotic systems. By the end of the course, students will understand the roles of small RNAs, riboswitches, and other RNA-based regulatory mechanisms in modulating gene activity.
Requirements: Basic knowledge of molecular biology, including transcription, translation, and RNA processing. Willingness to engage in discussions on RNA-based control mechanisms. Class and Presentations Scheduling: Pre-read relevant textbook materials, attentively listen to lectures, and actively participate in discussions.

Questions
How do small RNAs control gene expression in both prokaryotic and eukaryotic systems?

Readings, Websites or Video Clips
Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013)

Assignments for this session (if any)
None

Session 21
Technology, Health and Disease

Date: 6/5/2025

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)
Purpose: The purpose of this class is to explore the intersection of technology, health, and disease, focusing on how advancements in molecular biology are applied to understand and address health challenges. By the end of the course, students will understand key technologies in molecular biology, their applications in health and disease, and how these technologies contribute to our understanding of cancer, inherited diseases, and other health conditions.
Requirements: Basic understanding of molecular biology, including DNA, RNA, and gene expression. Class and Presentations Scheduling: Pre-read relevant textbook materials, attentively listen to lectures, and actively participate in discussions.

Questions
How have advancements in DNA sequencing technologies impacted our understanding of disease?
What are the differences between oncogenes and tumor suppressor genes, and how do these differences affect cancer development?
How do molecular techniques like EMSA and footprinting contribute to our understanding of nucleic acid-protein interactions?
How can understanding the molecular basis of inherited diseases lead to better diagnosis and treatment options?

Readings, Websites or Video Clips
Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013)

Assignments for this session (if any)
None

Questions
What are the differences between sRNAs in bacteria and miRNAs in eukaryotes?
How do riboswitches regulate gene expression, and what advantages do they offer in bacterial systems?
What role does the RNA-induced silencing complex (RISC) play in gene regulation, and how is its function influenced by the type of small RNA involved?
How does RNA interference (RNAi) contribute to gene silencing, and what are its potential applications in research and medicine?
What are the key differences between miRNAs, siRNAs, and piRNAs, and how do these differences affect their regulatory roles?

Readings, Websites or Video Clips
Molecular Biology of the Gene, 7th Edition (James D. Watson, et al. 2013)

Assignments for this session (if any)
None

About the instructor

Li Qing, Ph.D.

Dr. Li received her bachelor's degree in Biochemistry and Molecular biology from Peking University in 2001 and her Ph.D. from the same institution in 2006. She then conducted postdoctoral research at the Mayo Clinic Cancer Center in the United States from 2006 to 2011. In 2012, she established her independent research group at the School of Life Sciences, Peking University, and joined the Peking-Tsinghua Center for Life Sciences. Dr. Li was awarded the National Excellent Young Scientists Fund in 2013, the National Distinguished Young Scholars Fund in 2017, and the Ministry of Education Youth Science Award. In 2019, she was selected for the Beijing Outstanding Young Scientist Program.

Dr. Li and her lab focus on the regulation of chromatin replication, its impact on epigenetic inheritance, and the interplay between the epigenome and the genome. She has received both a university-wide Teaching Award and the School of Life Sciences Teaching Prize for Excellence in Undergraduate Education. Along with Dr. Wensheng Wei, she has co-instructed the Molecular Biology course for many years.

Current Position:

Boya Distinguished Professor, School of Life Sciences, Peking University

Investigator, Peking-Tsinghua Center for Life Sciences

Courses Taught

Molecular Biology (Undergraduate, Instructor)

Epigenetics: From chromatin biology to human disease (Undergraduate, Instructor)

Frontiers in Protein Sciences: From Beginner to Expert (Graduate, CLS Program)

About the instructor

Wei Wensheng, Ph. D.

Wensheng Wei earned his Bachelor's degree in Biochemistry from Peking University in 1991 and his PhD in Genetics from Michigan State University in 1999. Following his postdoctoral training and research associate role at Stanford University School of Medicine, he joined the School of Life Sciences at Peking University as a principal investigator in 2007. He currently serves as a professor in the School of Life Sciences, the Biomedical Pioneering Innovation Center (BIOPIC), and the Peking-Tsinghua Center for Life Sciences (CLS) at Peking University. His research primarily focuses on the development of advanced eukaryotic gene editing tools, with particular emphasis on high-throughput functional genomics and innovative approaches to cell and gene therapy.

Prof. Wensheng Wei has received numerous prestigious awards that highlight his significant contributions to life sciences, gene editing, and academic excellence. His accolades include the Wu Jieping-Paul Janssen Medical and Pharmaceutical Award, achievements in science and technology innovation during China's 13th Five-Year Plan, Tan Jiazhen Life Science Innovation Award, multiple teaching awards from Peking University, and industry recognitions such as the Boehringer Ingelheim Faculty Research Award and Bayer Investigator Award. He has also been honored for innovation and entrepreneurship, including the Beijing Advanced Worker Award, Beijing Science and Technology Award, and China Patent Award, reflecting his impact on both academia and translational research.

Current Position:

Professor, School of Life Sciences, Peking University

Professor, Biomedical Pioneering Innovation Center, and the Peking-Tsinghua Center for Life Sciences, Peking University

Course Title

Frontiers of Materials Science and Engineering

材料科学与工程专业英语

Instructor

Xiaoxu Zhao 赵晓续

First day of classes：February 17, 2025
Last day of classes：June 2, 2025
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(purpose, requirements, class and presentations scheduling, etc.)

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 structure and interatomic bonding

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Interaction between atoms, primary and secondary chemical bonds

Session 3
Crystalline and amorphous materialsz`

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Point groups, space group, Miller index, Nanocrystal, quasicrystals

Session 4
Defects and imperfections

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Point defects, line defects, planar defects, Defects engineering

Session 5
Electronic materials

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Semiconductors, n-doping, p-doping, Band structure, Chip technology

Session 6
Energy materials

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Lithium-ion battery, Cathode, anode, electrolyte, Supercapacitors

Session 7
Special topic

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Topics related with most advanced materials science research

Session 8
Review and discussions

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Review of last seven weeks and panel discussions

Session 9
Optical Materials

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Silicon materials, Perovskite materials, Conversion efficiency

Session 10
Magnetic Materials

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Magnetism and magnetic coupling, Altermagnetic materials

Session 11
Materials fabrication and processing part 1

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Wet chemistry, Chemical vapor deposition, Sputtering

Session 12
Materials fabrication and processing part 2

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Molecular beam epitaxy, Spin coat, etching, Nanodevice fabrication

Session 13
Student Presentation

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Student presentation on selected topics

Session 14
Materials characterization part 1

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Energy dispersive X-ray spectroscopy, X-ray diffraction, Optical microscopy

Session 15
Materials characterization part 2

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Transmission electron microscopy, Advanced electron microscopy

Session 16
Recent development in advanced low-dimensional materials

Description of the Session(purpose, requirements, class and presentations scheduling, etc.)

Graphene, hexagonal boron nitride, Transition metal dichalcogenides, Advanced 2D materials

About the instructor

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 160 peer reviewed papers including Nature, Nat. Nanotechnol, Nat. Mater, Nat. Commun., Sci. Adv., etc, with over 13,000 citations, h-index 60. He was named in the MIT Technology Review TR35 (Asia-Pacific) 2022.

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