1. 二课重点内容：

Key contents in Lecture 1-2

1. 生物医学光学技术的优势和特点；

The advantages and characteristics of biomedical optical technologies

1. 生物医学光学的发展趋势和挑战；

The trends and challenges of biomedical optical technologies

1. 光与生物组织相互作用的基本物理过程，以及衍生出来的生物光学方法和技术；

Light-tissue interactions and related optical techniques

1. 瑞利散射和米散射的特点比较；

Characteristics of Rayleigh scattering and Mie scattering

阅读任务：骆清铭老师《生物医学光子学》绪论、第一章

Reading assignment, Biomedical Photonics by Prof Qingming Luo, Introduction and Chapter 1,

作业：请用瑞利散射和米散射解释下列生活中的光学现象：蓝色的天空、白色的牛奶、黑色的乌云、红色的晚霞。（下次课之前一页A4纸交给TA）

Homework: Explain the following phenomena by Rayleigh scattering and Mie scattering: Blue sky, white milk, dark cloud, red sunset glow.

预习任务：赵凯华老师《光学》第二章：波动光学的基本原理

Reading assignment, Optics by Prof Kaihua Zhao, Chapter 2,3,4

第三、四课重点内容：

Key contents in Lecture 3-4

1. 光被生物组织散射产生的三种传输轨迹：弹道光子，蛇形光子，扩散光子； 分子的光吸收和激发弛豫过程

Light-tissue interactions; Three types of photons: ballistic, snaked, and diffused photons; Light absorption and relaxation processes of a molecule in Jablonski diagram;

1. 定态光波、简谐振子等概念；

Stable waveform; Simple harmonic oscillation;

1. 定态平面波的波函数；复振幅表示；

Wave function of plane wave; complex amplitude;

1. 定态球面波的波函数；复振幅表示；

Wave function of spherical wave; complex amplitude;

1. 两个光源产生静止干涉条纹的条件；

Mathematical description of the conditions for interference

阅读任务：赵凯华老师《光学》第二章、第三章、第四章

Reading assignment, Optics by Prof Kaihua Zhao, Chapter 2,3,4

第五课重点内容:

Key contents in Lecture 5

1. 相长干涉相消干涉与光程差/波长的关系;

Optical path difference, and relations between interference fringes and wavelength

1. 杨氏双狭缝干涉；

Young’s Double-Slit Experiment

1. 薄膜干涉、等倾干涉、等厚干涉；

Thin film interference, equal-inclination interference, equal-thickness interference

1. 迈克尔逊干涉仪的基本原理；

Michelson Interferometer

阅读任务：赵凯华老师《光学》第二章、第三章、第四章

Reading assignment, Optics by Prof Kaihua Zhao, Chapter 2,3,4

第六课重点内容:

Key contents in Lecture 6

1. 空间相干性、时间相干性 (相干长度、相干时间公式) 的基本概念；

Spatial coherence, Temporal coherence (Coherence length and coherence time);

1. 单缝衍射的条纹分布特征；

Single-slit diffraction pattern (Intensity distribution and wavelength dependence);

1. 光栅的工作原理；

The principle of diffraction grating;

1. 圆孔衍射、光学成像仪器分辨率、瑞利判据；

Diffraction of a circle aperture, Resolution of optical imaging instrument, Rayleigh criterion;

1. 显微镜的放大率、分辨率；

Magnification and resolution of a microscope;

阅读任务：务必详细研读赵凯华老师《光学》第二章第8节，例题1，3，4，5.（含有考试内容）

Reading assignment, Optics by Prof Kaihua Zhao, Chapter 2-8, Examples 1, 3, 4, 5

作业：Homework

1. 人眼对波长为550 nm波长的绿光最为敏感，瞳孔约为3 mm, 眼球直径约为25mm,

Assume the most sensitive wavelength for human eye is 550 nm, the pupil's diameter is 3 mm, the eyeball diameter is 25 mm,

1）估算眼睛瞳孔成像的艾里斑直径；

Estimate the diameter of Airy pattern for the human eye,

2）若物体放在距人眼25 cm (明视距离) 处，则两物点间距R为多大时才能被分辨？

An object is placed at a position 25 cm from the eye, what is the distance R can be resolved by the eye?

2. 用一架照相机在地面200km的高空拍摄地面上的物体，如果要求它能分辨地面相距1m的两点，照相机的镜头至少要多大？（设镜头没有几何相差，感光波长为500 nm）

A camera is placed at a position 200 km high from the earth surface, What is the diameter of the objective lens for the camera to resolve two points with a distance of 1 meter? (Assume the light wavelength used for imaging is 500 nm and there is no phase aberration for the lens)

第七课重点内容:

Key contents in Lecture 7

1. 吸收截面、吸收系数、推导Beer-Lambert Law；

Absorption cross section, absorption coefficient, derive Beer-Lambert law;

1. 散射截面、散射系数、约化散射系数；

Scattering cross section, scattering coefficient, reduced scattering coefficient;

1. DOT结构成像、功能成像、应用举例和优缺点；

DOT: Structural imaging, functional imaging, applications, pros and cons;

1. 组织光透明的基本原理。

Tissue optical clearing

作业Homework：

1. 推到Beer-Lamber定律，给出细节确定吸收截面和摩尔吸收系数的数值换算关系。

Derive Beer-Lambert law, give the details to correlate the absorption cross section absorption coefficient;

1. 一个盖玻片上均匀覆盖一层染料分子，设每个分子占据的面积是2 nm2，在550 nm波长的摩尔吸收系数是 100,000 M-1cm-1, 计算这层染料分子的吸光度。

Assume a glass coverslip is uniformly covered by a monolayer of dye molecules, each molecule occupies an area of 2 nm2 and has a molar coefficient of 100,000 M-1cm-1 at 550 nm, calculate the absorbance of the coverslip.

阅读任务：骆清铭老师《生物医学光子学》第四章、第九章

Reading assignment, Biomedical Photonics by Prof Qingming Luo, Chapter 4 and 9.

第八课重点内容:

Key contents in Lecture 8

1. 相干长度、相干时间的概念理解；相干长度与波长的关系公式；

Coherence length, coherence time, and related formula

1. OCT的基本原理、横向分辨率、轴向分辨率；轴向分辨率公式；

DOT: principle, longitudinal resolution, transverse resolution,

1. 时域OCT和频域OCT的基本原理、区别、优缺点

Time domain OCT, frequency domain OCT: principle, difference, pros and cons;

1. OCT的应用举例；

Application examples of OCT

阅读任务：骆清铭老师《生物医学光子学》第七章

Reading assignment, Biomedical Photonics by Prof Qingming Luo, Chapter 7.

第八课重点内容:

1. 激光多普勒成像和散斑成像的异同点；
2. 光镊的基本原理：单光束梯度力光学势阱的示意图；
3. 光镊在生物学研究中的优势和应用举例；
4. 动态光散射的基本原理、主要测量的物理参数（颗粒的水合尺寸和表面电位）；
5. 全息成像的基本思想、光路图，数字全息的基本原理，理解数字全息显微术；
6. 理解暗场显微术。

阅读任务：骆清铭老师《生物医学光子学》第八章、第十一章

第九课重点内容:

Key contents in Lecture 9

1. 理解发光的基本过程，Jablonski diagram；

Understanding the luminescence process in Jablonski diagram

1. 表征发光分子的四个重要参数：吸收截面、量子效率、寿命、光稳定性；

Four parameters to characterize a fluorophore, absorption cross section, quantum yield, lifetime, and photostability;

1. 单分子发光的激发饱和现象；

Excitation saturation in single molecule fluorescence;

1. 荧光染料、荧光蛋白、荧光抗体及应用；

Fluorescent dye, fluorescent protein, and fluorescent antibody

1. 荧光显微镜的基本结构, 显微镜放大率

Image formation in optical microscopy，magnification;

1. 物镜：数值孔径、分辨率、像差等概念；

Objective, numerical aperture, resolution, aberration,

阅读任务：骆清铭老师《生物医学光子学》第三章、第六章

Reading assignment, Biomedical Photonics by Prof Qingming Luo, Chapter 3 and 6.

第十课重点内容:

Key contents in Lecture 10

1. 激光共聚焦显微镜的组成部件、光路图；

Components of laser scanning confocal microscope, optical setup

1. 激光共聚焦显微术相对于普通荧光显微镜的优点；

Advantages of laser scanning confocal microscope

1. 转盘共聚焦显微术的工作原理、优点；

Principle and advantages of laser scanning confocal microscope

1. 流式细胞术的工作原理、应用；

Principle and applications of flow cytometer

阅读任务：骆清铭老师《生物医学光子学》第六章

Reading assignment, Biomedical Photonics by Prof Qingming Luo, Chapter 6.

第十一课重点内容:

Key contents in Lecture 11

1. 理解非线性光学现象的物理机制；

Understand nonlinear optical effect

1. 掌握多光子激发荧光与激发功率密度的关系；

Dependence of multiphoton excited fluorescence on excitation density

1. 理解two-photon action cross section；

Understand the two-photon action cross section

1. 理解飞秒激光平均功率、瞬时功率的关系；

Understand the average power and instantaneous power of ultrafast laser

1. 多光子成像的优点、缺点；

Advantages of multiphoton microscopy

1. 二次谐波成像的原理、特点；

Principle and properties of second harmonic generation

阅读任务：骆清铭老师《生物医学光子学》第六章

Reading assignment, Biomedical Photonics by Prof Qingming Luo, Chapter 6.

作业：推导双光子吸收截面和三光子吸收截面的单位。

Homework: derive the unit of two-photon absorption cross section and three photon absorption cross section

1. 二次谐波成像与双光子成像的区别和联系；
2. 4-Pi显微镜的原理；
3. Light-sheet显微镜的原理。

阅读任务：骆清铭老师《生物医学光子学》第六章

作业：推导双光子吸收截面和三光子吸收截面的单位。

第十二课重点内容:

Key contents in Lecture 12

1. 4-Pi显微镜的原理；

The principle and setup of 4-Pi microscopy

1. Light-sheet显微镜的原理;

The principle and setup of light-sheet microscopy

1. 理解单分子研究的必要性；

Why to study single molecule: static heterogeneity and dynamic heterogeneity

1. 理解单分子荧光探测的基本原理（样品浓度、荧光分子性质、仪器系统）；

Understanding the principle and requirements for single molecule fluorescence detection

1. 掌握荧光分子三能级系统的速率方程、稳态近似、解析各能级布局比例；
2. 计算特定激发功率密度下、某荧光分子的激发态和基态布局比值。

第十三课重点内容:

Key contents in Lecture 13

1. 掌握荧光分子三能级系统的速率方程、稳态近似、解析各能级布局比例；

Rate equations in three level system, steady-state approximation, excited state population and dynamics

1. 计算特定激发功率密度下、某荧光分子的激发态和基态布局比值。

Calculate the excited state population for a specific molecule at a given excitation density

1. 计算某荧光分子在特定激发功率密度下的发射光子数，经过显微系统收集，探测器的信噪比。

For a specific molecule at a given excitation density, calculate the number of emitted photons that is collected by a detector

1. 点扩展函数和显微镜的分辨率；

Point spread function and resolution of a microscope

1. 荧光定位显微术的基本原理，定位精度与探测光子数的关系；

Fluorescence localization microscopy, localization accuracy and photon number

1. STORM/PALM成像的基本原理

Principle of STORM and PALM

Homework：FITC molecule has a molar absorption coefficient of 73,000 cm-1M-1 and fluorescence lifetime of 4.2 ns. Consider a 488 nm laser beam of 1 mW was focused to a spot with a radius of 0.25 m. At this power density, how much is the probability of the single **FITC** molecule in the excited singlet state?

第十四课重点内容:

Key contents in Lecture 14

1. 自发辐射与受激辐射；

Spontaneous emission and stimulated emission

1. 激光的三个组成部分：泵浦源、增益介质、谐振腔；

Three components to make laser: pump source, lasing medium, and resonance cavity

1. STED的基本原理；

Principle of STED imaging

1. SIM的基本原理；

Principle of SIM imaging

第十五课重点内容:

Key contents in Lecture 15

1. 两个分子发生FRET的基本条件；

Basic conditions for FRET

1. FRET速率常数和FRET效率；

FRET rate constant and FRET efficiency;

1. 获得FRET效率的两种方法和公式：稳态荧光强度测量和时间分辨寿命测量；

Two methods to measure FRET efficiency

1. FRET应用举例；

Application examples of FRET