课程详述

COURSE SPECIFICATION

以下课程信息可能根据实际授课需要或在课程检讨之后产生变动。如对课程有任何疑问，请联系授课教师。

The course information as follows may be subject to change, either during the session because of unforeseen circumstances, or following review of the course at the end of the session. Queries about the course should be directed to the course instructor.

1.	**课程名称 Course Title**	**遗传学 Genetics**
2.	**授课院系 Originating Department**	生物系 Biology
3.	**课程编号 Course Code**	BIO301
4.	**课程学分 Credit Value**	3
5.	**课程类别 Course Type**	专业核心课(生物科学、生物技术、生物信息学） Major Core Courses(Biological Sciences, Biotechnology, Bioinformatics)
6.	**授课学期 Semester**	春季 Spring / 夏季 Summer / 秋季 Fall
7.	**授课语言 Teaching Language**	中英双语 English & Chinese
8.	**授课教师、所属学系、联系方式（如属团队授课，请列明其他授课教师） Instructor(s), Affiliation& Contact （For team teaching, please list all instructors）**	黄鸿达 Hongda Huang 生物系 Department of Biology huanghd@sustc.edu.cn
9.	**实验员/助教、所属学系、联系方式 Tutor/TA(s), Contact**	待公布 To be announced
10.	**选课人数限额(可不填) Maximum Enrolment （Optional）**	

11. 授课方式 Delivery Method	讲授 Lectures	习题/辅导/讨论 Tutorials	实验/实习 Lab/Practical	其它(请具体注明) Other（Please specify）	总学时 Total
学时数 Credit Hours	44			4 期中考试，复习辅导讨论 (Mid-term Exam, Tutorial/Revision/Discussion)	48

12.	**先修课程、其它学习要求 Pre-requisites or Other Academic Requirements**	None
13.	**后续课程、其它学习规划 Courses for which this course is a pre-requisite**	本课程为生物学专业的核心理论课之一，使学生建构全面的遗传学知识，为基因工程，表观遗传学，系统生物学，生物信息学等科目的学习奠定基础。 Genetics is the foundational course of Genetic engineering, Epigenetics, Systems biology, Bioinformatics and other advanced subjects.
14.	**其它要求修读本课程的学系 Cross-listing Dept.**	None 无

教学大纲及教学日历 SYLLABUS

15. 教学目标 Course Objectives

通过遗传学的学习，达到以下教学目标

1, 让学生全面了解和掌握遗传学的基本规律。

2, 在学习的过程中启发学生发现问题，解决并分析问题。

3, 激发学生进一步学习生命科学的兴趣。

Course objectives:

1. Providing an understanding of the principles of genetics.
2. Improving the students' problem solving skills.
3. To inspire students to further study biology.

16. 预达学习成果 Learning Outcomes

1, 让学生全面了解和掌握遗传学的基本规律。

2, 在学习的过程中启发学生发现问题，解决并分析问题。

3, 激发学生进一步学习生命科学的兴趣。

4,了解遗传学对社会的影响。

1. Providing an understanding of the principles of genetics.
2. Improving the students' problem solving skills.
3. To inspire students to further study biology.
4. The role of Genetics in society.

17. 课程内容及教学日历 （如授课语言以英文为主，则课程内容介绍可以用英文；如团队教学或模块教学，教学日历须注明主讲人）
Course Contents (in Parts/Chapters/Sections/Weeks. Please notify name of instructor for course section(s), if this is a team teaching or module course.)

1. Genes are DNA 2hrs

Introduction; Genetics and Heredity; The Chromosomal Basis of Inheritance; DNA is the genetic material; DNA is a double helix; DNA replication is semi-conservative; Nucleic acids hybridize by base pairing; Mutations change the sequence of DNA; Mutations are concentrated at hotspots; Recombination occurs by physical exchange of DNA; The genetic code is triplet; The relationship between coding sequences and proteins; cis-acting sites and trans-acting molecules; Genetic information can be provided by DNA or RNA; Introduction of prion.

2. From genes to genomes 2hrs

The nature of interrupted genes; Organization of interrupted genes may be conserved; Exon sequences are conserved but introns vary; Genes can be isolated by the conservation of exons; Genes show a wide distribution of sizes; Some DNA sequences code for more than one protein; How did interrupted genes evolve?

3. How many genes are there? 2hrs

Why are genomes so large? Eukaryotic genomes contain both nonrepetitive and repetitive DNA sequences; Most structural genes lie in nonrepetitive DNA; Total gene number is known for several organisms; How many genes are essential? How many genes are expressed? Organelles have DNA; Organelle genomes are circular DNAs that code for organelle proteins; Mitochondrial DNA codes for few proteins; The chloroplast genome codes for ~100 proteins and RNAs.

4. Clusters and repeats 2hrs

Gene clusters are formed by duplication and divergence; Sequence divergence is the basis for the evolutionary clock; Pseudogenes are dead ends of evolution; Unequal crossing-over rearranges gene clusters; Genes for rRNA form tandem repeats; The repeated genes for rRNA maintain constant sequence; Crossover fixation could maintain identical repeats; Satellite DNAs often lie in heterochromatin; Arthropod satellites have very short identical repeats; Mammalian satellites consist of hierarchical repeats; Minisatellites are useful for genetic mapping.

5. Messenger RNA 2hrs

Transfer RNA is the adapter; Messenger RNA is translated by ribosomes; The life cycle of bacterial messenger RNA; Translation of eukaryotic mRNA; The 5' end of eukaryotic mRNA is capped; The 3' terminus is polyadenylated; Bacterial mRNA degradation involves multiple enzymes; mRNA degradation involves multiple activities; Sequence elements may destabilize mRNA; Nonsense mutations trigger a surveillance system.

6. Protein synthesis 2hrs

The stages of protein synthesis; Initiation in bacteria needs 30S subunits and accessory factors; A special initiator tRNA starts the polypeptide chain; Initiation involves base pairing between mRNA and rRNA; Small subunits scan for initiation sites on eukaryotic mRNA; Eukaryotes use a complex of many initiation factors; Elongation factor T loads aminoacyl-tRNA into the A site; Translocation moves the ribosome; Three codons terminate protein synthesis; Ribosomes have several active centers.

7. Using the genetic code 2.5hrs

Codon-anticodon recognition involves wobbling; tRNA contains modified bases that influence its pairing properties; There are sporadic alterations of the universal code; tRNAs are charged with amino acids by synthetases; Accuracy depends on proofreading; The accuracy of translation; tRNA may influence the reading frame.

8. Protein localization 1hrs

Chaperones may be required for protein folding; Post-translational membrane insertion depends on leader sequences; A hierarchy of sequences determines location within organelles; Signal sequences initiate translocation; How do proteins enter and leave membranes? Anchor signals are needed for membrane residence; Bacteria use both co-translational and post-translational translocation; Pores are used for nuclear ingress and egress; Protein degradation by

proteasomes.

9. Transcription 2.5hrs

Transcription is catalyzed by RNA polymerase; The transcription reaction has three stages; A stalled RNA polymerase can restart; RNA polymerase consists of multiple subunits; RNA Polymerase consists of the core enzyme and sigma factor; Sigma factor is released at initiation; Sigma factor controls binding to DNA; Promoter recognition depends on consensus sequences; Promoter efficiencies can be increased or decreased by mutation; RNA polymerase binds to one face of DNA; Supercoiling is an important feature of transcription; Substitution of sigma factors may control initiation; Sigma factors may be organized into cascades; Sporulation is controlled by sigma factors; Bacterial RNA polymerase has two modes of termination; There are two types of terminator in E. coli; How does rho factor work? Antitermination is a regulatory event; Antitermination requires sites that are independent of the terminators.

10. The Operon 2.5hrs

Regulation can be negative or positive; Structural gene clusters are coordinately controlled; The lac genes are controlled by a repressor; The lac operon can be induced; Repressor is controlled by a small molecule inducer; cis-acting constitutive mutations identify the operator; trans-acting mutations identify the regulator gene; Multimeric proteins have special genetic properties; Repressor protein binds to the operator; Binding of inducer releases repressor from the operator; Repressor binds to three operators and interacts with RNA polymerase; Repressor is always bound to DNA; The operator competes with low-affinity sites to bind repressor; Repression can occur at multiple loci; Distinguishing positive and negative control; Catabolite repression involves the inducer cyclic AMP and the activator CAP; CAP functions in different ways in different target operons; CAP bends DNA; The stringent response produces (p)ppGpp; (p)ppGpp is produced by the ribosome; pGpp has many effects; Translation can be regulated; r-protein synthesis is controlled by autogeneous regulation; Phage T4 p32 is controlled by an autogenous circuit; Autogenous regulation is often used to control synthesis of macromolecular assemblies; Alternative secondary structures control attenuation; The tryptophan operon is controlled by attenuation; Attenuation can be controlled by translation; Small RNA molecules can regulate translation; Antisense RNA can be used to inactivate gene expression.

Mid-term exam 2hrs

11. Phage strategies 2hrs

Lytic development is divided into two periods; Lytic development is controlled by a cascade; Functional clustering in phages T7 and T4; Lambda immediate early and delayed genes are needed for both lysogeny and the lytic cycle; The lytic cycle depends on antitermination; Lysogeny is maintained by repressor protein; Repressor maintains an autogenous circuit; The repressor and its operators define the immunity region; Repressor dimers bind cooperatively to the operator; Repressor at OR2 interacts with RNA polymerase at PRM; The cII and cIII genes are needed to establish lysogeny; PRE is a poor promoter that requires cII protein; Lysogeny requires several events; The cro repressor is needed for lytic infection; What determines the balance between lysogenic and the lytic cycle?

12. The replicon 2hrs

Replicons can be linear or circular; Origins can be mapped by autoradiography and electrophoresis; The bacterial genome is a single circular replicon; Each eukaryotic chromosome contains many replicons; Isolating the origins of yeast replicons; D loops maintain mitochondrial origins; The problem of linear replicons; Rolling circles produce multimers of a replicon; Rolling circles are used to replicate phage genomes; The F plasmid is transferred by conjugation between bacteria; Conjugation transfers single-stranded DNA; Connecting bacterial replication to the cell cycle; Cell division and chromosome segregation; The division apparatus consists of cytoskeletal and regulatory components; Partitioning involves membrane attachment and (possibly) a motor; Multiple systems ensure plasmid survival in bacterial populations; Plasmid incompatibility is determined by the replicon; The ColE1 compatibility system is controlled by an RNA regulator.

13. DNA replication 2hrs

DNA polymerases are the enzymes that make DNA; DNA synthesis is semidiscontinuous; Coordinating synthesis of the lagging and leading strands; The replication apparatus of phage T4; Creating the replication forks at an origin; Common

events in priming replication at the origin; Does methylation at the origin regulate initiation? Licensing factor controls eukaryotic replication.

14. Recombination and repair 2hrs

Breakage and reunion involves heteroduplex DNA; Double-strand breaks initiate recombination; Bacterial recombination involves single-strand assimilation; Gene conversion accounts for interallelic recombination; Topological manipulation of DNA; Specialized recombination involves breakage and reunion at specific sites; Repair systems correct damage to DNA; Excision repair systems in E. coli; Controlling the direction of mismatch repair; Retrieval systems in E. coli; RecA triggers the SOS system; Eukaryotic repair systems.

15. Transposons 2hrs

Insertion sequences are simple transposition modules; Composite transposons have IS modules; Transposition occurs by both replicative and nonreplicative mechanisms; Transposons cause rearrangement of DNA; Replicative transposition proceeds through a cointegrate; Nonreplicative transposition proceeds by breakage and reunion; TnA transposition requires transposase and resolvase; Transposition of Tn10 has multiple controls; Controlling elements in maize cause breakage and rearrangements; Controlling elements form families of transposons; Spm elements influence gene expression; P elements are activated in the germline.

16. Rearrangement of DNA 2hrs

The mating pathway is triggered by pheromone-receptor interactions; The mating response activates a G protein; Yeast can switch silent and active loci for mating type; The MAT locus codes for regulator proteins; Silent cassettes at HML and HMR are repressed; Unidirectional transposition is initiated by the recipient MAT locus; Regulation of HO expression; Trypanosomes switch the VSG frequently during infection; New VSG sequences are generated by gene switching; VSG genes have an unusual structure; The bacterial Ti plasmid causes crown gall disease in plants; T-DNA carries genes required for infection; Transfer of T-DNA resembles bacterial conjugation; Selection of amplified genomic sequences; Transfection introduces exogenous DNA into cells; Genes can be injected into animal eggs; ES cells can be incorporated into embryonic mice; Gene targeting allows genes to be replaced or knocked out.

17. Chromosomes 2.5hrs

Condensing viral genomes into their coats; The bacterial genome is a nucleoid; The bacterial genome is supercoiled; Loops, domains, and scaffolds in eukaryotic DNA; Specific sequence attach DNA to the matrix; The contrast between interphase chromatin and mitotic chromosomes; Lampbrush chromosomes are extended; Polytene chromosomes form bands; Polytene chromosomes expand at sites of gene expression; The eukaryotic chromosome is a segregation device; Centromeres have short DNA sequences in S. cerevisiae; Centromeres may contain repetitious DNA; Telomeres are simple repeats that seal the ends of chromosomes; Telomeres are synthesized by a ribonucleoprotein enzyme.

18. Nucleosomes 2.5hrs

The nucleosome is the subunit of all chromatin; DNA is coiled in arrays of nucleosomes; Nucleosomes have a common structure; DNA structure varies on the nucleosomal surface; Supercoiling and the periodicity of DNA; The path of nucleosomes in the chromatin fiber; Organization of the histone octamer; Histones are modified; Reproduction of chromatin requires assembly of nucleosomes; Do nucleosomes lie at specific positions?; Are transcribed genes organized in nucleosomes? Histone octamers are displaced by transcription; DNAase hypersensitive sites change chromatin structure; Domains define regions that contain active genes; Heterochromatin propagates from a nucleation event; Heterochromatin depends on interactions with histones; X chromosomes undergo global changes; Chromosome condensation is caused by condensins; Methylation is perpetuated by a maintenance methylase; Methylation is responsible for imprinting; Epigenetic effects can be inherited; Yeast prions show unusual inheritance; Prions cause diseases in mammals.

19. Initiation of transcription 2hrs

Eukaryotic RNA polymerases consist of many subunits; Promoter elements are defined by mutations and footprinting; RNA polymerase I has a bipartite promoter; RNA polymerase III uses both downstream and upstream promoters; The

startpoint for RNA polymerase II; TBP is a universal factor; TBP binds DNA in an unusual way; The basal apparatus assembles at the promoter; Initiation is followed by promoter clearance; A connection between transcription and repair; Promoters for RNA polymerase II have short sequence elements; Some promoter-binding proteins are repressors; Enhancers contain bidirectional elements that assist initiation; Independent domains bind DNA and activate transcription; The two hybrid assay detects protein-protein interactions; Interaction of upstream factors with the basal apparatus.

20. Regulation of transcription 2hrs

Response elements identify genes under common regulation; There are many types of DNA-binding domains; A zinc finger motif is a DNA-binding domain; Steroid receptors are transcription factors; Steroid receptors have zinc fingers; Binding to the response element is activated by ligand-binding; Steroid receptors recognize response elements by a combinatorial code; Homeodomains bind related targets in DNA; Helix-loop-helix proteins interact by combinatorial association; Leucine zippers are involved in dimer formation; Transcription initiation requires changes in chromatin structure; Chromatin remodeling is an active process; Activation of transcription requires changes in nucleosome organization at the promoter; Histone acetylation and deacetylation control chromatin activity; Polycomb and trithorax are antagonistic repressors and activators; An LCR may control a domain; Insulators block enhancer actions; Insulators can vary in strength; A domain has several types of elements; Gene expression is associated with demethylation; CpG islands are regulatory targets.

21. Cell cycle And growth regulation 2.5hrs

Cycle progression depends on discrete control points; Checkpoints occur throughout the cell cycle; Cell fusion experiments identify cell cycle inducers; M phase kinase regulates entry into mitosis; M phase kinase is a dimer of a catalytic subunit and a regulatory cyclin; Protein phosphorylation and dephosphorylation control the cell cycle; Cdc2 is the key regulator in yeasts; Cdc2 is the catalytic subunit of mitotic cyclins and G1 cyclins; Cdc2 activity is controlled by phosphorylation and dephosphorylation; DNA damage triggers a checkpoint; CDC28 acts at both START and mitosis in S. cerevisiae; The animal cell cycle is controlled by many cdk-cyclin complexes; G0/G1 and G1/S transitions involve cdk inhibitors; Protein degradation is important in mitosis; Cohesins hold sister chromatids together; Exit from mitosis is controlled by the location of Cdc14; Reorganization of the cell at mitosis.

Tutorial/Revision/Discussion (2 hrs)

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

课程评估 ASSESSMENT

19.

评估形式 Type of Assessment	评估时间 Time	占考试总成绩百分比 % of final score	违纪处罚 Penalty	备注 Notes
出勤 Attendance				
课堂表现 Class Performance				
小测验 Quiz				
课程项目 Projects				
平时作业 Assignments				
期中考试				

Mid-Term Test				
期末考试 Final Exam				
期末报告 Final Presentation				
其它（可根据需要改写以上评估方式） Others (The above may be modified as necessary)				

20. 记分方式 **GRADING SYSTEM**

☑ A. 十三级等级制 **Letter Grading**
☐ B. 二级记分制（通过/不通过） **Pass/Fail Grading**

课程审批 REVIEW AND APPROVAL

21. **本课程设置已经过以下责任人/委员会审议通过**
This Course has been approved by the following person or committee of authority

本课程经生物系本科教学指导委员会审议通过。
This Course has been approved by Undergraduate Teaching Steering Committee of Department of Biology.