AGU Graduate School of Engineering and Science Bioengineering Program

COURSE RECORD

Code	BENG549
Name	Genome Editing: CRISPR
Hour per week	3 (3 + 0)
Credit	
ECTS	7.5
Level/Year	Graduate
Semester	
Type	Elective
Location	
Prerequisites	None
Special Conditions	
Coordinator(s)	
Webpage	
Content	The objective of this course is to introduce the concept of genome editing technology. We will be discussing the history of genome editing technologies (ZNF, TALEN and CRISPR/Cas9) and will be able to compare distinct methods for genome editing. We will design CRISPR experiments (sgRNA, vector selection or adoption of the vector-free system, screening strategy, CRISPR efficiency, specificity and safety, etc) from the beginning. CRISPR-mediated genome editing has opened doors to cure incurable human diseases and the extent to which CRISPR-mediated genome editing provides hope for these diseases will be discussed. We will discuss the applications of CRISPR/Cas9-mediated genome editing in a wide range of research. Finally, there will be a discussion of ethical aspects of genome editing technology.
Objectives	Genome Editing History: ZNF and TALEN, CRISPR: Prokaryotic Adaptive Immune System and CRISPR-Cas9 Technology; CRISPR-based Functional Analysis of Genes; CRISPR/Cas9 for Human Therapeutic (Cancer Therapy, mono-genetic diseases)
Learning Outcomes	LO1: learn Genome Editing History: ZNF and TALEN and,; CRISPR: Prokaryotic Adaptive Immune System; CRISPR-Cas9 Technology LO2: CRISPR design; CRISPR and DNA repair mechanism; CRISPR-mediated genome editing and human diseases LO3 : CRISPR-based Functional Analysis of Genes; CRISPR/Cas9 for Human Therapeutic (Cancer Therapy, mono-genetic diseases) LO4 : Cas9 like enzymes (Cas12a, Cas12b, Cas13, CasX, etc.); CRISPR Techniques: Gene activation, base editing, CRISPRi, RNA editing, Diagnosis etc.) LO5 : CRISPR and Ethics
Requirements	None
Reading List	**CRISPR paper for adaptive immunity in bacteria** Barrangou, R., Fremaux, C., Deveau, H., Richards, M., Boyaval, P., Moineau, S., Romero, D. and Horvath, P. (2007). CRISPR Provides Acquired Resistance Against Viruses in Prokaryotes. Science, 315(5819), pp.1709- 1712. **First CRISPR papers** ***In vitro*** Jinek, M., Chylinski, K., Fonfara, I., Hauer, M., Doudna, J. and Charpentier, E. (2012). A Programmable Dual-RNA-Guided DNA Endonuclease in Adaptive Bacterial Immunity. Science, 337(6096), pp.816-821. **Cell lines** Mali, P., Yang, L., Esvelt, K.M., Aach, J., Guell, M., DiCarlo, J.E., Norville, J.E., and Church, G.M. (2013). RNA-guided human genome engineering via Cas9. Science 339, 823–826

Cong, L., Ran, F.A., Cox, D., Lin, S., Barretto, R., Habib, N., Hsu, P.D., Wu, X., Jiang, W., Marraffini, L.A., and Zhang, F. (2013). Multiplex genome engineering using CRISPR/Cas systems. Science 339, 819–823

Qi, L., Larson, M., Gilbert, L., Doudna, J., Weissman, J., Arkin, A. and Lim, W. (2013). Repurposing CRISPR as an RNA-Guided Platform for Sequence-Specific Control of Gene Expression. Cell, 152(5), pp.1173-1183.

Review and others

Hille, F., Richter, H., Wong, S., Bratovič, M., Ressel, S. and Charpentier, E. (2018). The Biology of CRISPRCas: Backward and Forward. Cell, 172(6), pp.1239-1259.

Wright, A., Nuñez, J. and Doudna, J. (2016). Biology and Applications of CRISPR Systems: Harnessing Nature's Toolbox for Genome Engineering. Cell, 164(1-2), pp.29-44.
Fellmann, C., Gowen, B., Lin, P., Doudna, J. and Corn, J. (2016). Cornerstones of CRISPR–Cas in drug discovery and therapy. Nature Reviews Drug Discovery, 16(2), pp.89-100.

Wang, H., La Russa, M. and Qi, L. (2016). CRISPR/Cas9 in Genome Editing and Beyond. Annual Review of Biochemistry, 85(1), pp.227-264.

Amitai, G. and Sorek, R. (2016). CRISPR–Cas adaptation: insights into the mechanism of action. Nature Reviews Microbiology, 14(2), pp.67-76.

Abadi, S., Yan, W., Amar, D. and Mayrose, I. (2017). A machine learning approach for predicting CRISPRCas9 cleavage efficiencies and patterns underlying its mechanism of action. PLOS Computational Biology, 13(10), p.e1005807.

Anders, C., Niewoehner, O., Duerst, A. and Jinek, M. (2014). Structural basis of PAM-dependent target DNA recognition by the Cas9 endonuclease. Nature, 513(7519), pp.569-573.
Dominguez, A., Lim, W. and Qi, L. (2015). Beyond editing: repurposing CRISPR–Cas9 for precision genome regulation and interrogation. Nature Reviews Molecular Cell Biology, 17(1), pp.5-15.

Aird, E., Lovendahl, K., St. Martin, A., Harris, R. and Gordon, W. (2018). Increasing Cas9-mediated homology-directed repair efficiency through covalent tethering of DNA repair template. Communications Biology, 1(1).

CRISPR and Evolution

Koonin Eugene V. and Makarova Kira S. Origins and evolution of CRISPR-Cas systems374Phil. Trans. R. Soc. B

Human Diseases and CRISPR

M. Tabebordbar, K. Zhu, J. K. W. Cheng, W. L. Chew, J. J. Widrick, W. X. Yan, C. Maesner, E. Y. Wu, R. Xiao, F. A. Ran, L. Cong, F. Zhang, L. H. Vandenberghe, G. M. Church, A. J. Wagers(2016). In vivo gene editing in dystrophic mouse muscle and muscle stem cells. Science 351, 407–411

C. E. Nelson, C. H. Hakim, D. G. Ousterout, P. I. Thakore, E. A. Moreb, R. M. C. Rivera, S. Madhavan, X. Pan, F. A. Ran, W. X. Yan, A. Asokan, F. Zhang, D. Duan,

	C. A. Gersbach, (v2016). In vivo genome editing improves muscle function in a mouse model of Duchenne muscular dystrophy. Science 351, 403–407 Zhang, Y., Long, C., Li, H., McAnally, J., Baskin, K., Shelton, J., Bassel-Duby, R. and Olson, E. (2017). CRISPR-Cpf1 correction of muscular dystrophy mutations in human cardiomyocytes and mice. Science Advances, 3(4), p.e1602814.
Ethical Rules and Course Policy	

LEARNING ACTIVITIES *Please, use this one as a reference for your course*

Activities	**Number**	**Weight (%)**
Lecture	3	25%
Group Works	8	25%
Presentations	7	25%
Site Visits	1	25%
	Total	100

ASSESSMENT

Evaluation Criteria	**Weight** (%)
Quizzes	00%
Weekly Assignments	00%
Group Project Assignments & Presentations	10%
Attendance/Participation	10%
Midterm Exam	30%
Final Exam/Submission	50%
Total	100%

For a detailed description of grading policy and scale, please refer to the website https://goo.gl/HbPM2y section 28.

COURSE LOAD *Please, use this one as a reference for your course*

Activity	**Duration** (hour)	**Quantity**	**Work Load** (hour)
In class activities	2	14	28
Lab	1	7	7
Group work	2	12	24
Research (web, library)	2	12	24
Required Readings	2	10	20
Pre-work for Presentation	2	7	14
Lab reports	1	7	7
		General Sum	**124**

ECTS: 4 (Work Load/25-30)

CONTRIBUTION TO PROGRAMME OUTCOMES*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14
LO1	5	5	5	5	5	5	5	5						
LO2	5	4	4	4	4	4	5	5						
LO3	5	4	4	4	4	4	4	4						
LO4	5	4	4	4	4	4	4	4						

* Contribution Level: 0: None, 1: Very Low, 2: Low, 3: Medium, 4: High, 5: Very High

WEEKLY SCHEDULE

W	**Topic**	**Outcomes**
1	Genome Editing History: ZNF and TALEN Lab/Activity:	LO1
2	CRISPR: Prokaryotic Adaptive Immune System Lab/Activity:	LO1
3	CRISPR-Cas9 Technology Activity:	LO1
4	CRISPR and DNA repair mechanism; Activity:	LO2
5	CRISPR design; Activity:	LO2
6	CRISPR-mediated genome editing and human diseases Activity:	LO2
7	Examples of CRISPR/Cas9-mediated genome editing 1 Activity:	LO3
8	Model organisms and CRISPR Activity:	LO1, LO3
9	CRISPR-based Functional Analysis of Genes Activity:	LO3
10	CRISPR/Cas9 for Human Therapeutic (Cancer Therapy, mono-genetic diseases, etc) Activity:	LO3, LO4
11	CRISPR/Cas9 Evolution and Cas9 like enzymes (Cas12a, Cas12b, Cas13, CasX, etc.) Activity:	LO1, LO2, LO4
12	CRISPR Techniques (Gene activation, base editing, CRISPRi, RNA editing, Diagnosis etc.) Activity:	LO1, LO2, LO4, LO5
13	Examples of CRISPR/Cas9-mediated genome editing 2 Activity:	LO4
14	CRISPR and Ethics Activity:	LO5

Prepared by
Date