**Genes, traits, and morphs**

**Study guide and reading assignments**

**The numbers in front of each study question correspond to slide numbers, as presented during lecture.**

**Reading assignments:** Abstract, Introduction and Conclusions required. Rest of papers optional. The papers can be downloaded, as pdfs, from Canvas – they are in the “Files” folder.

1. Taketa et al. Nud gene.
2. Ueta et al. CRISPR tomato.

1 What is the importance of polymorphism in genetic analysis?

2 Briefly genotype, phenotype, and trait.

2 What does “cds” refer to in a GenBank nucleotide entry?

3 What process is involved in going from DNA to RNA?

3 What process is involved in going from RNA to protein?

3 What is a lemma, what is a palea, and what is their agricultural relevance?

3 Shortly after domestication, ~ 10,000 years ago, the naked allele was selected by eaters of barley and the covered allele was selected by brewers of barley. Why?

4 Briefly define locus, gene, allele and describe how these terms are related.

5 What are the genetic features underlying the *Nud* allele and the *nud* allele? Why is *Nud* dominant to *nud*?

5 Is it possible to distinguish between *Nud Nud* and *Nud nud* genotypes based on phenotype?

6 Draw a nucleotide of DNA. Label the three principal components and label the carbon atoms in the 5-carbon sugar.

7 Given the sequence ATG, draw the corresponding polymer of nucleotides and label the 5’ and 3’ ends of the molecule (assuming this is the sense strand).

8,9 Compare and contrast the starting and end points of transcription and translation.

8,9 In the *Nud* gene example, the non-highlighted DNA sequence is removed and the highlighted sequences are joined. What is the non-highlighted sequence called?

9 Are all plant genes like *Nud*, with just one intron?

9 Using the codon translation table provided in the class notes,

What is the translation of the first three bases of the *Nud* gene?

What is the translation of the last three bases of the *Nud* gene?

9 Using the codon translation table provided in the class notes,

What is the translation of the first three bases of your favorite gene in your favorite plant?

What is the translation of the last three bases of your favorite gene in your favorite plant?

10 What is the function of a gene promoter, and where is it found?

10 Compare and contrast definitions for intron and exon.

10 Compare and contrast definitions for 5’ and 3’ UTR.

10 In what ways do other genes, pathways, and environmental signals relate to whether not a seed is covered vs. naked? Do you think this level of complexity is the exception or the rule in plant genetics?

11 What is a transcription factor?

12 What does “ERF” stand for in the context of transcription factors?

12 What is ethylene and what role does it have in plants?

13 *From the assigned reading (Taketa et al. 2008)*.

* Since the *Nud* gene is a transcription factor, does it directly encode the lipid gum that is responsible for the lemma and palea adhering to the seed coat?
* Is it correct to say that the hull adherence trait is controlled by a single gene (*Nud*)?
* In terms of DNA sequence, what is the principal difference between the *Nud* and the *nud* alleles?
* What are the four lines of evidence that Taketa et al. used to prove that they cloned the *Nud* gene?
* Define “pleiotropy”.
* Which of the following is most likely?
* The *nud* mutation was selected for once and then dispersed by early agriculturalists.
* The nud mutation occurred repeatedly and at different times and locations throughout the world.
* What types of mutations leading to *nud* alleles are described by Taketa et al.?

14,15 Compare and contrast the phenotypic manifestations of monomorphism vs. polymorphism from generation to generation.

16, 17 What advantages and disadvantages are there to recording reliable and cost-effective data on naked eye polymorphisms vs. DNA-level polymorphisms?

16,17 Reflect on the role of dominance and heterozygosity in terms of the utility of NEP vs. DNA polymorphisms.

18 Briefly describe and define the types of changes in DNA sequence that will lead to polymorphisms.

19 Are changes in DNA sequence more likely to be causal (in terms if change in phenotype) if they are in (a) exons or (b) introns?

20 If neutral DNA polymorphisms do not affect phenotype, why are they of potential interest and utility?

21 Briefly define and describe five attributes of naturally occurring mutations.

22 Give an example of how naturally occurring mutations have played a key role in generating economic value in apples. What advantage do apples have, over barley, in terms of plant breeders being able to capitalize on naturally occurring mutations?

23, 24 What considerations are the same, and which are different, for naturally occurring mutations and mutations induced by ionizing radiation and/or chemicals?

24 Give an example of a chemical mutagen and its value to horticulture.

25,26 How do DNA replication errors and repair processes relate to mutations?

27 Give an example of how a deletion mutation can lead to a premature stop codon.

28 Describe another type of change in DNA sequence, besides a frameshift, that can lead to a stop codon.

29 If mutations are changes in DNA sequence, how could their effect on phenotype be due to changes in sequence, changes during transcription and/or changes during translation?

30, 31 If you get your dream job – as a geneticist working on your favorite plant – what is the appeal of CRISPR-Cas9 mutagenesis vs. mutagenesis by radiation or chemicals?

31,32 Define the CRISPR and Cas9 acronyms.

31, 32 Based on the Nature video accessed via the [CRISPR-Cas hyperlink](https://www.youtube.com/watch?v=4YKFw2KZA5o) and the overview/opinion TED talk accessed via the [A powerful source of genetic variation](https://www.youtube.com/watch?v=1BXYSGepx7Q) hyperlink, answer the following questions.

* Briefly explain where the system is naturally occurring and what it does in that situation.
* What is meant by “gene editing”?
* What are the two principal components of the CRISPR-Cas9 system and what are their roles?
* How does the CRISP-Cas9 complex identify a specific target in the genome?
* What type of break does Cas9 make in the host double helix, and why is this break important?
* What is meant by “knocking out” a gene?
* Is gene “knock out” all that CRISPR-Cas 9 can do?
* Is CRISP-Cas9 really cheap and easy? Why or why not?

33 Explain the role of plant hormones in seed formation in tomato and how CRISPR-Cas9 gene editing could be used to create seedless tomatoes.

33 From the assigned reading by Ueta et al.

* What is the importance of parthenocarpy in tomato?
* What gene did the authors target for gene editing, and why?
* According to the authors, was their targeted mutation strategy successful?
* Were there any off-target mutations?
* Were there any pleiotropic effects of the edited gene?

34 Having completed this unit, what new perspectives do you have on genes, traits, and monomorphisms/polymorphisms?

**Synthesis questions**

Why would a CRISPR-Cas9 gene editing system for inducing parthenocarpy be useful in tomato but not in wheat?

If you wanted to create a naked barley from a covered barley, using CRISPR-Cas9 gene editing, why would it be important to know how many other ERF transcription factors there are in the barley genome, and how they differed in sequence from the *Nud* gene?

How many alleles are possible at a locus?

What types of genetic analyses are possible in a plant that can only be propagated by vegetative methods?