AP Bio FRQ Fridays

2019 #1
Gene Expression, Feedback, & Ecological Interactions

FRQ Friday #25

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Auxins are plant hormones that coordinate several aspects of root growth and development. Indole-3-acetic acid (IAA) is an auxin that is usually synthesized from the amino acid tryptophan (Figure 1). Gene *Trp-T* encodes an enzyme that converts tryptophan to indole-3-pyruvic acid (I3PA), which is then converted to IAA by an enzyme encoded by the gene *YUC*.

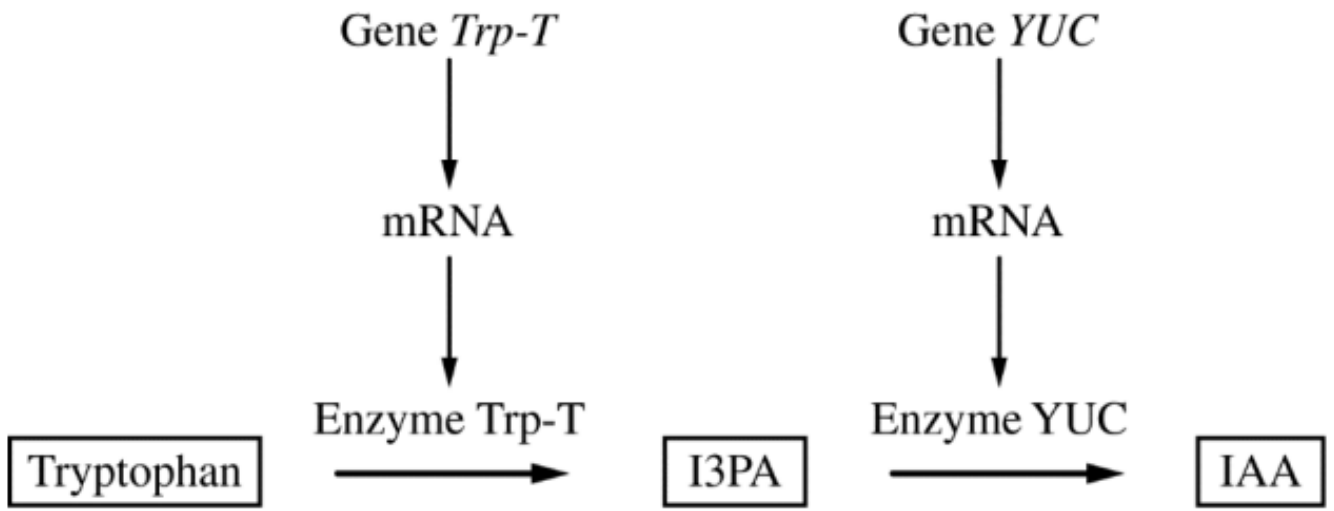

Figure 1. Model of two-step enzymatic plant pathway for synthesis of IAA from tryptophan

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(a) **Circle** ONE arrow that represents transcription on the template pathway. **Identify** the molecule that would be absent if enzyme YUC is nonfunctional.

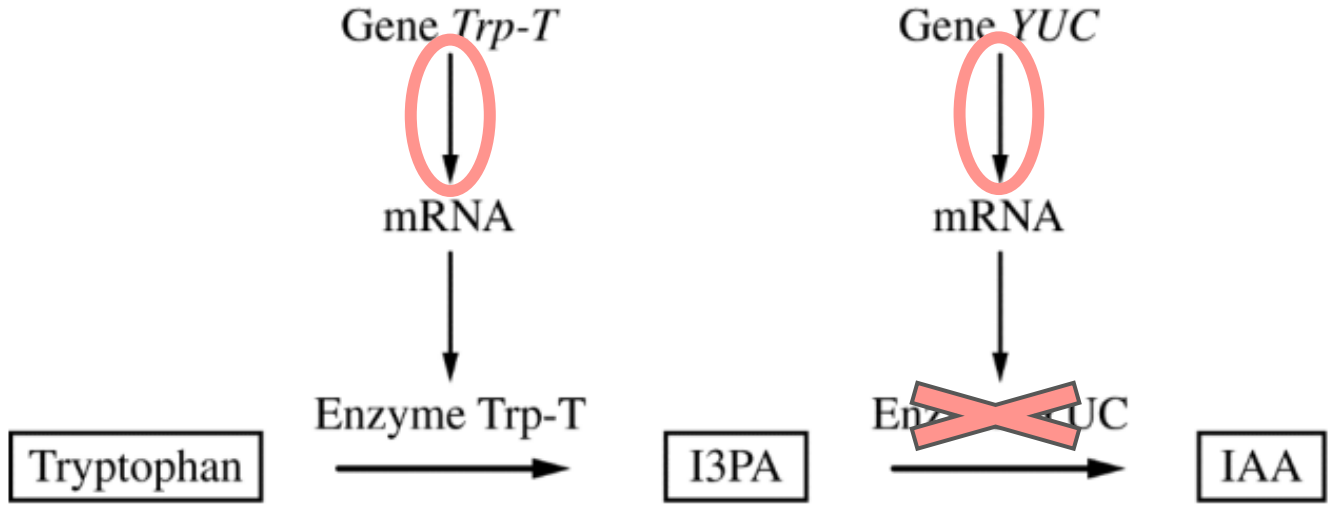

Figure 1. Model of two-step enzymatic plant pathway for synthesis of IAA from tryptophan

Circle (1 point)

- Circle around either arrow pointing from a gene (*Trp-T* or *YUC*) to mRNA

Identification (1 point)

- IAA

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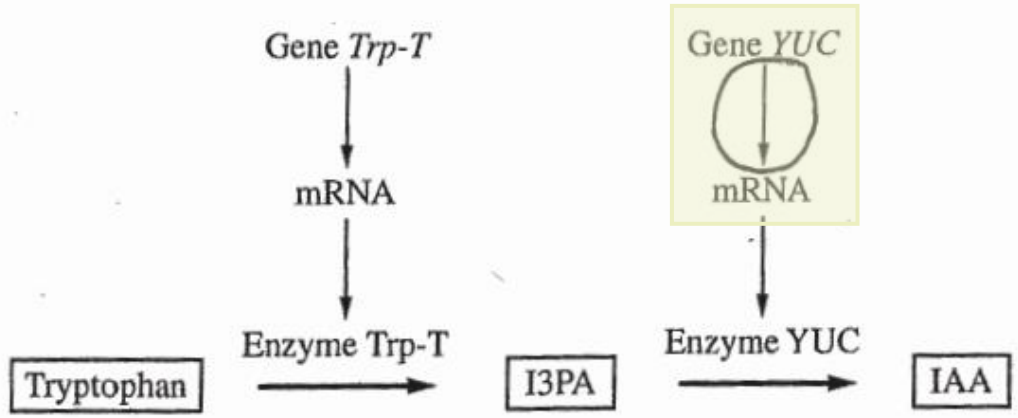

Figure 1. Model of two-step enzymatic plant pathway for synthesis of IAA from tryptophan

a) See diagram for circled arrow. If Enzyme YUC is nonfunctional, IAA will be absent.

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(b) **Predict** how the deletion of one base pair in the fourth codon of the coding region of gene *Trp-T* would most likely affect the production of IAA. **Justify** your prediction.

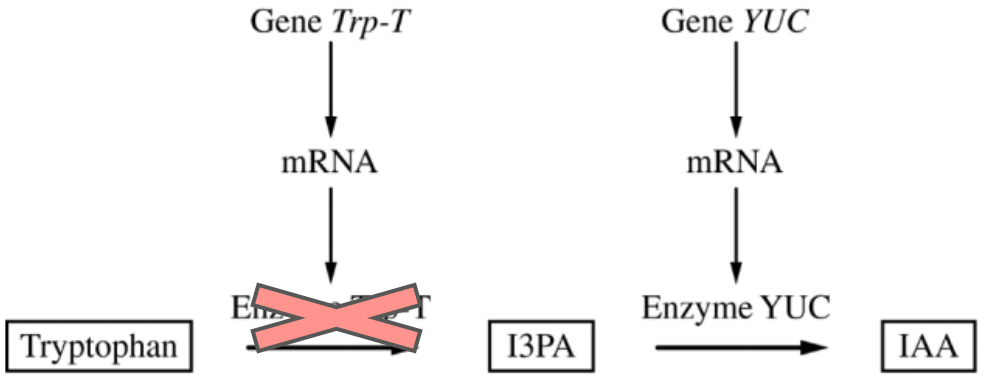

Figure 1. Model of two-step enzymatic plant pathway for synthesis of IAA from tryptophan

Prediction (1 point)

- Reduction in IAA production OR No production of IAA

Justification (1 point)

- The mutation will result in the translation of an inactive/nonfunctional Trp-T enzyme.
- The mutation will result in no translation of the Trp-T enzyme.
- The mutation will result in no/reduced production of I3PA.

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- The mutation will result in the translation of an inactive/nonfunctional Trp-T enzyme.
- The mutation will result in no translation of the Trp-T enzyme.
- The mutation will result in no/reduced production of I3PA.

b) The described deletion would likely significantly reduce IAA production. This is because a deletion of a base pair in a gene often causes a frame shift, which alters all subsequent codons in the gene. As the corresponding mRNA is translated, the altered codons append different amino acids than intended, resulting in a Trp-T Enzyme that is non-functional due to a differing primary structure.

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(c) **Explain** one feedback mechanism by which a cell could prevent production of too much IAA without limiting I3PA production.

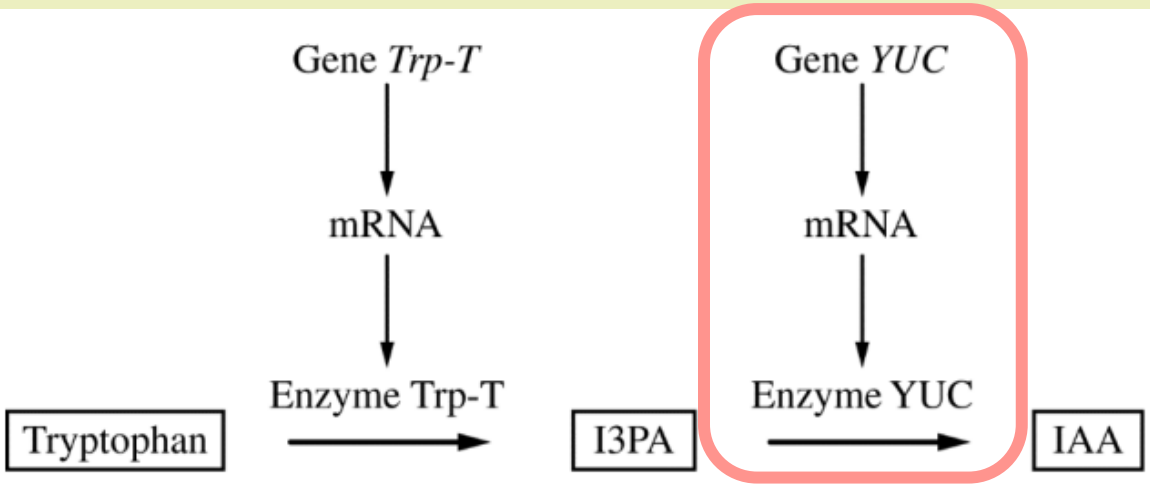

Figure 1. Model of two-step enzymatic plant pathway for synthesis of IAA from tryptophan

Explanation (2 points)

- Negative feedback/feedback inhibition/increasing amounts of IAA inhibits the pathway.
- Production of YUC enzyme is inhibited OR YUC enzyme activity is inhibited.

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Explanation (2 points)

- Negative feedback/feedback inhibition/increasing amounts of IAA inhibits the pathway.
- Production of YUC enzyme is inhibited OR YUC enzyme activity is inhibited.

c) To limit IAA production without limiting I3PA production, a cell would need a negative feedback loop that prevents Enzyme YUC availability in the presence of excess IAA. An example could consist of epigenetic markers produced in the presence of IAA that prevent transcription of the YUC gene, temporarily halting Enzyme YUC production.

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(d) Rhizobacteria are a group of bacteria that live in nodules on plant roots. Rhizobacteria can produce IAA and convert atmospheric nitrogen into forms that can be used by plants. Plants release carbon-containing molecules into the nodules. Based on this information, **identify** the most likely ecological relationship between plants and rhizobacteria. **Describe** ONE advantage to the bacteria of producing IAA.

Identification (1 point)

- Mutualism

Recall: IAA is an auxin that coordinates root growth and development

Description (1 point)

- Increases habitat/number of nodules for the rhizobacteria.
- The bacteria receive carbon/carbon-containing molecules (as a result of increased plant growth).

d) The most likely ecological relationship between the plants & the rhizobacteria is mutualism. An advantage for the bacteria producing IAA is that the host roots will grow & develop in the presence of the IAA auxin, expanding the bacteria's habitat & ensuring the survival of the plant on which it depends.

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(e) A researcher removed a plant nodule and identified several "cheater" rhizobacteria that do not produce IAA or fix nitrogen. **Describe** the evolutionary advantage of being a bacterial cheater in a population composed predominantly of noncheater bacteria. Plants can adjust the amount of carbon-containing molecules released into nodules in response to the amount of nitrogen fixed in the nodule. **Predict** the change in the bacterial population that would cause the plant to reduce the amount of carbon-containing molecules provided to the nodule.

Description (1 point)

- Cheaters/bacteria that benefit without producing IAA/fixing nitrogen have more energy for reproduction.

Prediction (1 point)

- Decrease in the nitrogen-fixing/noncheater bacteria
- Decrease in the amount of nitrogen fixed (by bacteria)

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Description (1 point)

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Prediction (1 point)

- Decrease in the nitrogen-fixing/noncheater bacteria
- Decrease in the amount of nitrogen fixed (by bacteria)

c) Bacterial cheaters have an evolutionary advantage because they expend less energy on producing IAA + fixing nitrogen than non-cheaters, giving them more energy to seek resources + reproduce and therefore increasing their fitness. Due to this advantage, the bacterial population will exhibit a hire cheating frequency in subsequent generations. This results in less nitrogen fixation in the plant's root nodules, which would cause the plant to reduce carbon compound release in response.