	Integrative Taxonomy Why and how should we use statistics to describe species?	**Name:** **Group color:** **Group number:**

Learning goals:

- Understand and differentiate between discovery, delimitation/validation and species description (i.e. "formalization"), as well as their value in the light of the ongoing biodiversity crisis.
- Learn to use statistical tools to compare the values of morphological characters between closely related lineages.
- Understand the difference between diagnostic and non-diagnostic characters.
- Understand the importance and limitations of using different sources of data (morphological, ecological, genetic, etc.) in species discovery, delimitation and description.
- Understand the strengths and limitations of using integrative taxonomy when conducting species descriptions.

Learning outcomes:

- Students will use different data types to evaluate and identify lineages as candidate species.
- Students will evaluate the relevance of different morphological characters for differentiating species.
- Students will be able to interpret, compare and synthesize different ways of describing species.
- Students will statistically evaluate the variation of morphological characters between lineages using appropriate software and algorithms.
- Students will expand upon your own knowledge, previous experiences, and intellectual abilities. How? By criticizing positions of colleagues that agree and disagree with you.

Activity 1: Understanding other authors

(*Grouping by color*)

Task A: Organize yourselves into groups by color. Read the article assigned to your group and respond to the following questions:

1. What type of evidence is used to evaluate speciation?
   Some possible options: geographical evidence, molecular evidence, morphological evidence, etc.

2. What type of data was collected? Possible options: qualitative (nominal *vs.* ordinal) or quantitative (discrete *vs.* continuous).

3. Have the data been analyzed in a statistical framework? Why or why not? Possible options: yes, no → Explain why.

4. Is the evidence presented in the article sufficient to describe a species as new? NOTE: *Remember! All of these species are currently valid!*

5. Regardless of the previous answer, how would you improve the work?

(*Forming composite groups. Instructor's Note: if not possible to regroup, do this step by shared discussion.*)

Task B: Regroup so that each new group contains only 1 member from each original color group; ideally, this regrouping will be based on a group number assigned to you in addition to group color. Now, go around the group, and briefly compare your answers to the following questions (starting with the person who read Paper 1, moving in sequence to person who read Paper 4):

6. Is it necessary to use statistics in the description of species? Why?

7. Is there a community-wide standard practice used to describe species? Why?

[*Regroup by color (original groups)*]

Task C: Form original groups again (by color). Now that you have an idea of what the other groups learned from their papers, discuss the following questions with your group:

8. Is there a better or worse way of describing species, and if so, Why?

9. What data types would *you include* in a species description study, and Why?

Homework assignment

(*You can think and discuss in a group, but the answers you come up with should be individual.*)

Read these 4 articles, making sure to <u>read them in the following order</u>:

- Paper 3 - Leaché & Fujita (2010)
- Paper 5 - Bauer et al. (2010)
- Paper 6 - Fujita & Leaché (2014
- Paper 7 - Wagner et al. 2014

After reading the article by Leaché & Fujita (2010), answer the following question:

10. What types of evidence do Leaché & Fujita (2010) use to recognize and describe species?

After reading the article by Bauer et al. (2010), answer the following questions:

11. What types of evidence do Leaché & Fujita (2010) use to recognize and describe species?

12. List at least two of the arguments that the authors use to invalidate the species names of Leaché & Fujita (2010).

13. List the rules of the International Code of Zoological Nomenclature (which appear in Bauer et al. 2010) that have to be taken into account to make proposals for valid names and species.

14. According to the authors, how can Leaché & Fujita's (2010) approach serve the biodiversity crisis?

15. What kind of taxonomic approaches do you recommend using now?

Read Fujita & Leaché's (2010) response to Bauer et al. (2010). Now answer the following questions:

16. What is "taxonomic inflation?" What is the opposite of this?

17. Why does taxonomic instability occur? What is the effect of this on the Biodiversity Crisis?

18. What do the authors propose to stabilize the taxonomy?

19. What are the main differences (that the authors present) between molecular data and morphological data?

Read the article by Wagner et al. (2014) and answer the following questions:

20. Why do they describe the same species that was described by Leaché & Fujita (2010)?

21. What evidence did they use to describe the new species?

Taking into account your prior knowledge as well as what you learned by reading all of the above articles (in class and for the homework), do the following:

22. Draw a flow chart (connected words with explanations of the connections) including the following words:

Species discovery; species delimitation; species description; taxonomy; International Code of Zoological Nomenclature; biodiversity crisis; taxonomic stability; Generalized Lineage Concept of Species (species concept).