Subject/Problem

What is an animal? Although this may sound like a simple question, the answer is actually quite complicated and can vary depending on culture and personal experience. There is the scientific concept of 'animal', which refers to the kingdom animalia, but there are also several everyday definitions of animal. For instance, many definitions are rather human-centered, such as excluding humans from the animal group, thereby putting humans in their own group by themselves (Tanner 1994; Lee 1997; Hurn 2012; Waldau 2013). Other definitions may only include animals that humans knowingly interact with, such as domesticated animals (Lee 1997; Waldau 2013). The existence of multiple definitions of 'animal' can also be observed by examining the definitions provided in a dictionary. In the Merriam-Webster dictionary (2013), the first definition is quite broad and scientific, referring to the kingdom *Animalia*. The second definition, on the other hand, portrays the more human-centered definition described above by stating "a: one of the lower animals as distinguished from human beings; b: mammal; *broadly*: vertebrate" ('Animal' 2013).

Although multiple definitions of 'animal' exist, the concept of 'animal' used by natural philosophers/scientists has remained fairly consistent since the time of Aristotle. Aristotle (350 B.C.E./1994-2000), in his book *Historia Animalium* (History of Animals), described animals as having organs that allow for the ability to eat and sense, such as touch. Some are also able to move while others are sessile. Aristotle provided such examples as horses, fish, sponges, and even humans. Several centuries later, these characteristics were still used by Lamarck (1914/1963), but he further stressed the organization within the body and that all animals are able to move to some extent. Moreover, Whittaker (1969), while proposing the five-kingdom system, still used the traits described by Aristotle and Lamarck, but also described cellular characteristics, such as multicellularity and not having cell walls.

Although the scientific definition has remained fairly consistent throughout the centuries and is taught in introductory biology, Waldau (2013) argued in his book *Animal Studies: An Introduction* that professors and students of biology will continue to use the everyday definitions of animals since it is more acceptable in society. Is this argument, however, justified? How do upper-level biology majors (i.e., biology students that have completed their introductory courses and have been formally taught about classification) conceptualize the concept of animals? In order to answer this question, we completed a study that consisted of survey and interview. Our specific research questions were:

1. Do students have multiple conceptions of animals?
2. Do students hold any misconceptions regarding the scientific definition of animal?

Design or Procedure

Participants. The targeted population for this study was upper-level undergraduate students with a biology or biology-related major (see Table 1 for sample characteristics). All participants were from the same university but from four different courses that were upper-level biology courses whose professor was willing to volunteer class time for the study. No differences (chi-square tests; $\alpha = 0.05$) in age, gender, class, or number of biology courses taken were found between the

courses. Differences in number of biology and biomedical students were significant between courses ($x^2 = 16.0$; $p = .01$), which were expected since two ecology-based and two physiology-based courses were used. These two majors are required to take the same introductory courses.

Table 1. Sample characteristics ($N = 59$)

Major	Class	Gender	Age	Course
Biology ($n = 31$)	Juniors ($n = 11$)	Males ($n = 30$)	Range: 20-39 years	Ornithology ($n = 23$)
Biomedical ($n = 26$)	Seniors ($n = 48$)	Females ($n = 29$)	(75% between 21-23 years)	Neuroethology ($n = 6$)
Secondary Education ($n = 2$)				Great Lakes Environment ($n = 18$)
				Synthetic Biology ($n = 12$)

Survey. A survey to assess students' conceptions of the term 'animal' was developed by the primary researcher and validated by both university professors that taught the required introductory organismal biology course and by the primary investigator, who was a teaching assistant for the course. The survey was administered in each of the four courses during the first half of the semester; the date varied due to professor convenience. It was facilitated by the primary investigator using a PowerPoint presentation, and participants completed the survey on individual answer sheets. There were five parts to this survey and participants were given one part at a time so that they could not go back and change any answers on previous parts. Part A of the survey asked for demographic information. Part B asked the students to 'List 5 types of animals.' This question is slightly modified from Trowbridge and Mintzes (1985, 1988), Chen and Ku (1998), and Yen et al. (2007). The purpose of this question was to determine what students conceptualized when they first heard the term 'animal' while sitting in their biology classroom. Part C asked participants to 'List 5 types of animals. This time, make sure to have your list as representative of the entire diversity of the animal kingdom as possible.' The second part of this question has not been used in previous studies and explicitly asked about diversity in order to determine how students conceptualized the animal kingdom, without being presented with explicit examples.

Table 2. Examples used in Parts D and E.

Part D: Pictures	Part E: Terms
Paramecium (Protist)	*Paramecium*
Mushroom (Fungus)	Protist
Venus Flytrap (Plant)	Mushroom
Sponge	Venus Flytrap
Jellyfish	Sponge
Coral	Jellyfish
Marine Flatworm	Coral
Roundworm	Marine Flatworm
Earthworm	Roundworm
Squid	Earthworm
Snail	Squid
Beetle	Snail
Butterfly	Beetle
Spider	Butterfly
Starfish	Spider
Sea Urchin	Starfish
Sea Squirt	Sea Urchin
Western-dressed Human	Sea Squirt
Non-western-dressed Human	Human
Cat	Cat

Part D consisted of 20 colored photographs with a Creative Commons or similar license that was presented to the participants via the PowerPoint presentation. The animals in the survey were selected in order to cover several animal phyla (Table 2). Participants were shown only the picture, not the term associated with the picture, nor were participants told what the image represented. Participants were asked to answer 'Is this an animal?' for each picture. The same or similar question was used in previous studies (e.g., Bell, 1981; Bell & Barker, 1982; Chen and Ku, 1998; Tema, 1989; Trowbridge & Mintzes, 1988; Villalbí & Lucas, 1991) but with different examples. For each picture, participants were provided with the options of 'yes' and 'no,' a free-response for why they chose their answer, and a Likert scale to measure their level of certainty (i.e.,

extremely certain, quite certain, somewhat certain, not at all certain). The final part, Part E, was similar to Part D, except instead of pictures, terms were used. Similar examples from Part D were used (see Table 2) along with a similar answer sheet that allowed participants to answer the question 'Is this an animal?', why they chose their answer, and how certain they were about each answer. The name was not read aloud to them. Participants were not told that the pictures and terms were of the same examples, but, according to the interviews, several noticed that they were the same. In order to ensure that seeing the pictures before seeing the terms did not impact their answers on the terms, two courses were shown the pictures before the terms, and the other two were shown the terms before the pictures. For each course that was studied, the order of the pictures and the terms was randomly selected.

Interview. Participants were contacted for a semi-structured interview after the primary investigator had examined their answers to the survey and had obtained the monetary incentives, which was four to seven weeks after they took the survey. The interview sample (N =25) was representative of the survey sample (15 biology majors and 10 biomed majors, 5 juniors and 20 seniors, 12 males and 13 females, and average age was 22 years). Each interview lasted approximately 15-30 minutes and was completed one-on-one with the participant and the primary investigator in a private room. For each interview, the interviewer had the participant's answer keys and a hard-copy of the PowerPoint used during the participant's course.

The interview was used to validate and clarify the survey responses by looking for consistency between the survey and interview answers. In order to better understand their conception of the term 'animal' participants were asked how they distinguished animals from non-animals. For the specific questions on the survey regarding animals, participants were asked how confident they felt while they were answering and what they were thinking about that triggered their responses.

Data Analysis. For data analyses, all courses were combined since no significant differences were found between survey answers ($\alpha = 0.05$). Most of the data were analyzed via frequency analyses. When statistical tests were completed, only non-parametric tests, such as the Independent-Samples Kruskal-Wallis test, were used since the data did not pass tests of normality. The p-value was adjusted accordingly in all situations; for example, the critical p-value for questions based on naming five animals was .05/5 = .01. For the free-response in the surveys and for the interviews, answers were analyzed primarily by frequency and qualitative analyses. Since this was an exploratory study, a coding dictionary was not created until after the data were collected. Coding was completed by the primary investigator.

Analyses and Findings

Question #1. Do students have multiple conceptions of animals?

Results

Participants were first asked to name five types of animals (Part B) and then to name five types of animals that represent the animal kingdom (Part C). For Part B, over 70% of survey participants listed only vertebrates (Figure 1) and, overall, most (89%) terms were types of vertebrates. Almost half of the participants listed mostly mammals (i.e., at least three of the five

terms), but about half of the total participants also listed at least one bird, one non-avian reptile, and/or one fish (Figure 1). Of the top ten terms listed by participants (Table 3), all of the terms were types of vertebrates and most were broad, such as 'mammal.' Of those terms that were species-specific, only 'dog,' 'cat,' 'lion,' and 'cow' (assuming 'cattle' was meant) were on the top-ten list.

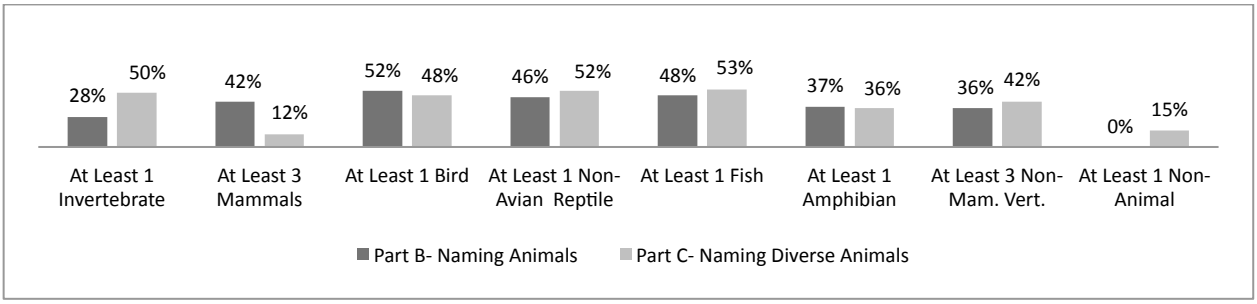

Figure 1. Participants (%) that had listed terms in the selected categories when asked to name five animals (Part B) and to name five representative animals (Part C). "Non-mam. vert." = non-mammalian vertebrates; "non-animal" = non-animal organisms.

Table 3. Top ten terms listed when participants were asked to name five types of animals (Part B) and then five types of representative animals (Part C).

Part B- Naming Animals		**Part C- Naming Representative Animals**	
Top 10 Terms	% of Participants (N = 59)	Top 10 Terms	% of Participants (N = 59)
Dog	41% (n = 24)	Mammal	42% (n = 25)
Bird	37% (n = 22)	Reptile	36% (n = 21)
Reptile	34% (n = 20)	Fish	34% (n = 20)
Mammal	32% (n = 19)	Amphibian	30% (n = 18)
Cat	29% (n = 17)	Bird	25% (n = 15)
Fish	27% (n = 16)	Arthropod	14% (n = 8)
Amphibian	25% (n = 15)	Insect	14% (n = 8)
Lion	12% (n = 7)	Cnidaria	10% (n = 6)
Cow	10% (n = 6)	Invertebrate	10% (n = 6)
Frog	10% (n = 6)	Vertebrate	10% (n = 6)

Once we asked participants to create lists of representative animals (Part C), most of the lists were different from the ones made for Part B. For the new lists, many more participants (50%) listed at least one invertebrate (Figure 1), and of the total terms, twice as many terms (23%) were types of invertebrates. Far fewer participants (12%) listed mostly mammals; however, some participants (15%) provided non-animals, in the scientific sense, such as bacteria (Figure 1). Of the top ten terms listed, the top five were still vertebrates, but invertebrates were listed for the next four (Table 3). None of the top terms were species-specific; participants likely chose broad terms in order to cover more animals, as seven participants described during the interview. Four participants included both terms 'vertebrate' and 'invertebrate.' Oddly, the term 'cnidaria' was used by six participants, which is the phylum that includes jellyfish, corals, and sea anemones. When asked why during an interview, one participant replied "I think maybe because you didn't really remember what it was but like you could remember the term." Another participant during an interview stated that he just thought "It [cnidaria]'s an interesting group."

Next, participants were shown a series of pictures and terms and asked to identify if each was an animal or non-animal and to explain why. Internal reliability was measured via Cronbach's α. It was strong for pictures (.72) and terms (.74) and even stronger for pictures and terms combined (.86). Overall, participants did well in identifying which were animals in the pictures (M = 17.9 out of 20) and terms (M = 17.8 out of 20). Of the 20 examples, 14 were invertebrates. Therefore, although only 50% of participants listed at least one invertebrate on their representative list, when explicitly asked about specific invertebrates, most participants recognized them as animals, indicating a use of the scientific definition of animal.

Conclusion

As indicated by this study, students hold multiple conceptions of animal, and which definition used depended on the situation/task. When students were asked to first name types of animals, not surprisingly, responses were primarily vertebrates, especially mammals. Then when participants were asked to list five types of animals that represented the animal kingdom, participants' lists included more invertebrates, but lists were still vertebrate driven. On the other hand, when shown specific examples, which most were invertebrates, students used the scientific definition and considered most invertebrates as animals. Interestingly, these results occurred even though the surveys were administered in biology classrooms. Therefore, it is important to remind students, even upper-level biology students, of the scientific definition of 'animal' when discussing animals. This can also be true of other concepts that have both everyday and scientific meanings, such as adaptation, work, energy, force, experiment, theory, law, and model.

Question #2. Do students hold any misconceptions regarding the scientific definition of animal?

Results

Although, on average, students were able to use the scientific definition of 'animal' when labeling organisms as an animal or non-animal, there were a few examples that commonly confused participants, which were the *Paramecium*, sponge, coral, and sea squirt (see Figures 2 & 3, Table 4). Four participants indicated in their free-response that the picture of the protist was a single-celled animal. Therefore, students recognized the image as a single cell, but did not recognize that that all animals are multicellular. During the interviews, nine of the 25 interviewees also seemed confused on if an organism had to be multicellular to be considered an animal, which several stated it was not a requirement. Instead of multicellularity, participants may have, instead, been focused on movement, as five specifically stated that protists are animals due to movement. Nearly half of the participants also named the term '*Paramecium*' as a non-animal. Since this is not a colloquial name, it was not surprising that even several participants that correctly circled it as a non-animal also indicated that they were not at all certain (n = 11) or only somewhat certain (n = 13).

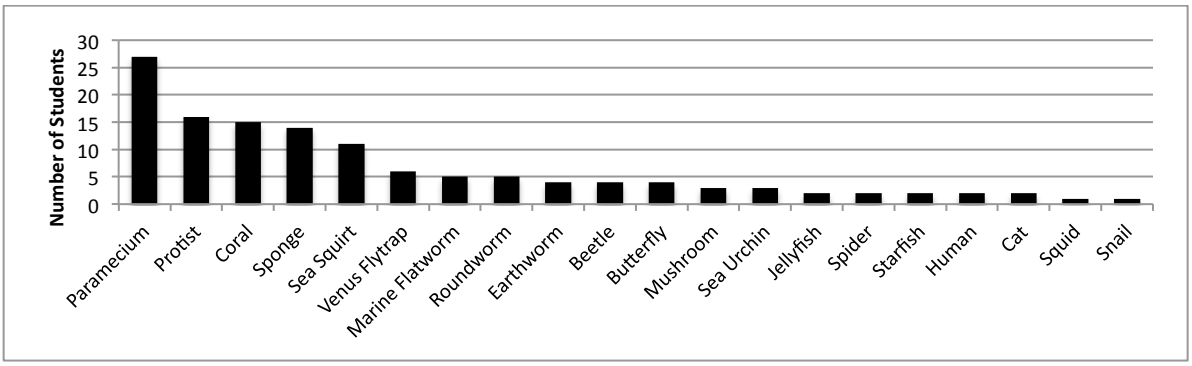

Figure 2. Number of students that did not use the scientific concept of 'animal' for the pictures.

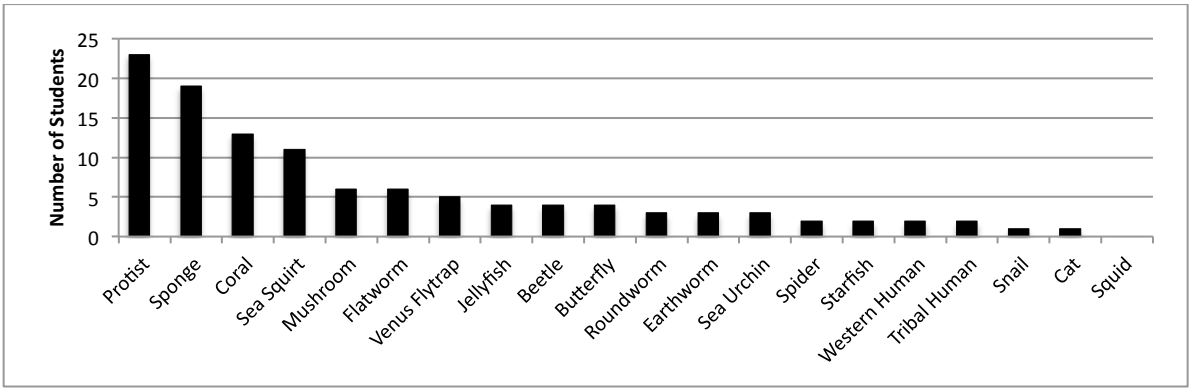

Figure 3. Number of students that did not use the scientific concept of 'animal' for the terms.

Table 4. Common alternative conceptions of pictures.

Alternative Conception	**Common Reasoning Provided in Free Response**
Protists are animals (*n* = 23)	Protists are animals due to movement (*n* = 5)
Sponges are not animals (*n* = 19)	Sponges are plants (*n* = 7)
Corals are not animals (*n* = 13)	Corals are plants (*n* = 6)
Sea Squirts are not animals (*n* = 11)	

For the sponges and corals, whether the picture or the term, several participants indicated that they were plants. For instance, from the pictures, four participants called both the sponges and the corals plants, three stated that the sponges were plants and two participants called the corals plants (Table 4). Similar findings were discovered for the terms themselves. A few of these participants were interviewed as well. One participant mentioned that he thought that corals were plants because "they don't move" and "they can be … photosynthetic." Participants were also confused on the picture and the term 'sea squirt.' However, for several participants, they were completely unsure of what it was.

Only three survey participants used the narrower definition of 'animal', selecting only vertebrates as animals (Figures 2 and 3). Interestingly, one participant indicated that only invertebrates are animals. The reasoning that he provided for each invertebrate was "cold blooded, living," and the human and cat was not an animal in all instances because they are "warm blooded." However, when asked to name animals before completing this task, he listed a dog, cat, frog, fish, and lizard, and for naming diverse animals, he provided vertebrates, invertebrates, warm blooded, cold blooded, and bacteria. Therefore, his definition of the term 'animal' was very unclear from this survey, and he possibly changed his mind while taking the

survey. Unfortunately, we were not able to interview this participant for further clarification. Another participant marked the picture of the cat as a non-animal, but human as animal, stating that the cat was not an animal "because they suck." Fortunately, this participant was interviewed. When asked about it, the participant replied "I guess I didn't take that question seriously, I'm not a cat person, I guess that was immature. I'm so sorry. I'm embarrassed." Therefore, only one participant appeared to believe that the cat, and possibly mammals, in general, was a non-animal.

Only one participant labeled humans as non-animals but still labeled the cat as an animal. Moreover, this participant also labeled the insects as non-animals. This participant provided little reasoning in the free-response portion of the survey. For the human, he stated "not sure how to explain it." However, for his list of diverse animals he provided *Drosophila* (insect), crustaceans, mammals, birds, and invertebrates. Therefore, this participant's definition of the term 'animal' also was difficult to understand from this survey. Unfortunately, we were also unable to interview this participant.

Participants' explanations as to why something was or was not an animal varied, but all but one participant used its classification at least once. The average number of times that a participant would use classification as a reason in the survey was 23 times (out of 40 possibilities), which was higher than using characteristics of animals. For instance, for the beetle, one participant only wrote "beetles are part of the animal kingdom," and for the cat, another participant wrote "felines are mammals which are animals." However, participants' classifications were not always scientifically correct, such as a squid is an animal because it is an "amphibian" or a jellyfish is a "type of fish." These scientifically incorrect classifications were, however, rare. Occasionally, participants would admit that they had memorized it as being an animal, but did not know why. For instance, "I can't really describe why this [marine flatworm] is an animal but I know it is from class."

Table 5. Common (i.e., at least 10% of participants stated) animal kingdom characteristics listed for why an animal is an animal.

Characteristic[1]	% of Participants (N = 59)
Heterotrophic/Eat	49% (n = 29)
Movement	46% (n = 27)
Not unicellular	41% (n = 24)
Has nervous system	19% (n = 11)
Does not perform photosynthesis	17% (n = 10)
Multicellular	17% (n = 10)
Has appendages	15% (n = 9)
Has eyes	14% (n = 8)
Can think/decide	12% (n = 7)
Has symmetry	12% (n = 7)
Has digestive system	12% (n = 7)
Does not have chloroplasts	10% (n = 6)

[1] Characteristics were provided in participants' free-response portion of the survey.

Participants also discussed characteristics of the animal kingdom to describe if something was or was not an animal. All but five participants did this. The average number of times that a participant would use this type of reasoning was about 11 times. The most commonly used characteristic was to eat (n = 29/59; Table 5). The next most common characteristic described was movement. Trying to consider if the organism could move or not may be a reason why some

participants were able to use the scientific definition of 'animal' for most of the examples but not the few that commonly caused problems. As one interviewee noted, "it's the coral, the sea squirt and the sponge that I had trouble with. I think it was just the movement that I was looking at."

Although some participants had difficulty determining if all animals were multicellular, as described above, not being unicellular was the next most commonly provided trait (n = 24; Table 5). Having a nervous system (n = 11) or being able to think (n = 7) were also fairly common responses. A few participants also used the characteristic of having a digestive system (n = 7). Oddly, participants sometimes stated that an organism was an animal due to having appendages, tentacles, or legs (n = 9), eyes or eyespots (n = 8) or some other physical features, such as a spider having "appendages, head, abdomen, thorax, [and] exoskeleton." Furthermore, plants were often labeled as non-animals because they are photosynthetic, producers, or autotrophic (n = 12).

Occasionally, participants used characteristics of living organisms, in general, to explain if something was or was not an animal. Forty participants used these types of characteristics; many used these characteristics along with characteristics specific to the animal kingdom. The most common responses were because it reproduces (n = 21) and it is living or alive (n = 19). Respiration was also somewhat common (n = 10), as well as interacting and responding to the environment (n = 7). For instance, the sponge is an animal because "it's alive, it reproduces, and interacts with other species." Surprisingly, eight participants referred to an organism's sea habitat in their reasoning, such as "these [flatworms] are sea life and are part of the animal kingdom." Overall, participants provided a great diversity of reasons as to why an organism was or was not an animal.

Conclusion

All in all, participants were able to use the scientific definition of 'animal' when asked about a series of organisms. However, some of these upper-level biology students were still maintaining misconceptions, such as sessile animals are plants and all moving organisms are animals. These misconceptions are likely due to students focusing on the characteristic of movement. Therefore, while teaching about animals, it is important to discuss multiple characteristics of animals, such as having organs for eating and sensing, organization within the body, and multicellularity. Moreover, because of the confusion regarding sessile animals, it is essential that the issue of sessile animals is explicitly addressed when introducing the subject of animals. One way to do this is to discuss with students why such a behavior may have evolved in animals, which most of these animals are filter feeders and not active predators or foragers.

Wrap-Up

In summary, it appears that upper-level biology students hold multiple conceptions of the term 'animal', and which conception students utilize can vary with situation. If explicitly reminded of invertebrates, students can use the scientific definition of animal, but some students still hold misconceptions regarding animals. These misconceptions seem to be primarily related to the ability to move, such as sessile animals are plants and all moving organisms are animals. Therefore, it is also important to explicitly discuss sessile and mobile animals.

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