

## *Simultaneous Measurement of the Acceptance of the Theory of Evolution at Regionally Distinct Colleges*

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### ABSTRACT

The Measurement of the Acceptance of the Theory of Evolution (MATE) survey has 20 statements that a respondent evaluates. We transcribed the MATE into an online survey delivered to Introductory Biology students by email. Six items were added at the front of the MATE to capture descriptive demographic information: Gender, ethnicity or race, religious identity, academic major, academic class, and college. The average acceptance score for evolution was 69.6 ( $s=16.20$ ,  $N=140$ ) out of a possible 100 points. The three survey items where students were most undecided about evolution were: 1) “*With few exceptions, organisms on earth came into existence at about the same time,*” 2) “*The theory of evolution cannot be tested scientifically,*” and 3) “*The theory of evolution cannot be correct since it disagrees with the Biblical account of creation.*”

Statistical analysis found that the overall acceptance of evolution was dependent on the student’s religious identity or the college that they attended. By using this survey in Introductory Biology, before instruction on evolution, at three different and distant colleges (Mid-Atlantic and Southwest), we identified the evolutionary concepts that our Introductory Biology students have difficulty accepting. This information can then be used to develop a strategy to address student misconceptions.

*“Nothing in biology makes sense except in light of evolution.”<sup>1</sup>*  
Theodosius Dobzhansky,

### INTRODUCTION

The scientific theory of evolution broadly explains “why” biologists observe all of life’s known traits, properties, and functions. Evolution both explains what biologists have observed and predicts what biologists might observe through research. Because of its power to explain and predict in a unified scientific context, science education organizations have called for a level of instruction on evolution that matches its central and unifying place in biology. In *Vision and Change in Undergraduate Biology Education A Call to Action* (2011), the American Association for the Advancement of Science identifies evolution as a “core concept for biological literacy” in the understanding of all undergraduates (Bauerle 2011 p. 12).

The Measurement of the Acceptance of the Theory of Evolution (MATE) is a survey that was published in 1999 (Rutledge & Warden, 1999). This survey has 20 statements that a

respondent evaluates (by strength of agreement or disagreement) using a Likert-scale. The ultimate objective of this survey<sup>1</sup> is to measure a person's overall acceptance of evolutionary theory. The MATE survey has been statistically validated in its ability to assess accurately assess a person's acceptance of evolution with high school biology teachers (Rutledge & Warden, 1999), Pre-service science teachers (Ha, Haury, & Nehm, 2012), and undergraduate students (Ingram & Nelson, 2006; Rutledge & Sadler, 2007; Moore & Cotner, 2009a; Moore & Cotner, 2009b; Rutledge & Sadler, 2011; Walter, Halvorsen, & Boyce, 2013).

In this study, we asked Introductory Biology students at three colleges to complete the MATE survey at the beginning of the Fall 2014 term before any instruction of evolution. Data gathered from these surveys allowed us to measure the level of evolutionary theory acceptance for students from three different colleges. By administering the survey at three different colleges, we were able to assess the attitudes toward evolution for students with a wide variety of ethnicities, religious identities, academic majors, and class standings. Our results also allowed us to identify both the evolutionary concepts that Introductory Biology students have the greatest acceptance of, as well as those concepts these students struggle with the most. Armed with this information, we believe we will be able to develop enhanced instructional strategies that both promote teaching evolution more effectively and which achieve more successful learning of evolution by students.

### **METHOD**

Introductory Biology students (Fall 2014) at three colleges participated in this project: D'Youville College, Texarkana College, and Texas A&M University-Texarkana. D'Youville College (DYC) is a private Catholic college in Buffalo, NY. It has nearly 3,200 students (67% Undergraduate, 33% Graduate) enrolled in over 45 degree programs. Academic programs include bachelor's, master's, post-baccalaureate, doctoral, and advanced certificate programs. Texarkana College (T.C.) in Texarkana, TX, is a public, two-year, comprehensive community college. T.C. has more than 4,000 students earning associate degrees, workforce certificates, and dual credit hours. Texas A&M University-Texarkana (TAMTU) in Texarkana, TX, is a public university. It has 1,800 students registered in 17 undergraduate degree programs and ten graduate degree programs.

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<sup>1</sup>1. Theodosius Dobzhansky, "Nothing in Biology Makes Sense Except in the Light of Evolution," *American Biology Teacher*, 35, no. 3 (1973):125-129.

The MATE was transcribed into an online survey using the online service [www.sogosurvey.com](http://www.sogosurvey.com). The online survey was delivered to each student individually by email. A link to the survey was included in the contact email as well as a request that students complete the survey. In the contact email, students were assured that their responses would remain anonymous and that their participation, or lack thereof, would not affect their grade in Introductory Biology. All students received the link to the survey by email at the beginning of the semester before instruction of evolution (August 25, 2014). Students were given until September 9, 2014, to complete the survey. This date was selected because this was the last day to add the course at one of the participating institutions.

Six items were added at the front of the MATE to capture descriptive demographic information: Gender, ethnicity or race, religious identity, academic major, academic class with the associated number of earned credit hours, and college (Appendix 1). To assure students that they would not be identified by their demographic traits, students were not required to answer these items. The MATE survey has 20 statements that the respondent evaluates (by the strength of agreement or disagreement) using a Likert-scale (Appendix 2). Students were required to complete these 20 items. Six optional items were added to the end of the MATE survey to gather relevant data on evolution instruction in high school and to determine students' self-identification as either creationists or evolutionists (Appendix 3).

In the MATE survey, ten items measure the student's acceptance of evolution and ten items measure the student's rejection of evolution (Appendix 2). For the acceptance of evolution items, student responses were scored as follows: Strongly Agree=5, Agree=4, Undecided=3, Disagree=2, and Strongly Disagree=1. For the rejection of evolution items, student responses were scored as follows: Strongly Agree=1, Agree=2, Undecided=3, Disagree=4, and Strongly Disagree=5. A student's overall acceptance of evolution is measured by the sum of all 20 standard MATE survey item codes. Complete acceptance of evolution is indicated by overall response score of 100. Complete rejection of evolution is indicated by an overall response score of 20.

A one way ANOVA was used to determine if the overall response score varied significantly ( $p < 0.05$ ) with each of the six demographic variables: Gender, ethnicity or race, religious identity, academic major, academic class, and college. If a significant difference

between demographic groups was identified, then Fisher's pairwise least square difference (PLSD) test was used to identify which pair of groups differed significantly from each other in their average overall response score.

### RESULTS

Although 76 Introductory Biology students at NYC completed the survey, not all survey items were answered, some items were given multiple answers, and some required items were unanswered by respondents. These discrepancies in responses necessitated that some results be excluded from analysis. This produced sample sizes between 71 and 76 for any individual survey item evaluated. For the NYC survey, 46 responding students were female and 29 were male. The ethnic and racial makeup of the responding NYC students was primarily white ( $N=58$ ), followed by African-American ( $N=6$ ), Asian ( $N=5$ ), Hispanic ( $N=3$ ), American Indian ( $N=1$ ), and multiracial ( $N=1$ ). In terms of religious identity, 40 of NYC responding students were Catholic, ten were Atheistic/Agnostic, six were Mainline Protestant, five were Christian and five were Muslim, three had no religious identity, two were Buddhist, while Hinduism, Judaism, and not religious were each represented by one student. The academic majors of Introductory Biology at NYC students were Biology, Bachelor of Science (BIO BS,  $N=55$ ); Biology, Bachelor of Arts (BIO BA,  $N=11$ ); Business ( $N=3$ ), Biology, Education (BIO ED,  $N=2$ ); and pre-pharmacy ( $N=2$ ). Lastly, 15 of responding NYC students were incoming freshmen (0 credit hours), 35 were continuing freshmen (1-30 credit hours), seven were sophomores (31-60 credit hours), nine were Juniors (61-90 credit hours), and six were Seniors (91+ credit hours).

Fifty-two Introductory Biology students at T.C. completed the survey. As with the NYC surveys, some survey items were not answered or given multiple answers, and respondents did not answer some required items. This necessitated the trimming of responses and produced sample sizes between 48 and 52 for any survey item examined. For the T.C. survey, 32 of the surveyed students were female and 20 were male. The ethnic and racial makeup of T.C. responding students was primarily white ( $N=40$ ), followed by African-American ( $N=8$ ), Hispanic ( $N=2$ ), American Indian ( $N=1$ ), and Asian ( $N=1$ ). In terms of religious identity, 22 of T.C. surveyed Introductory Biology students were Evangelical Christian/Protestant, eight were Catholic, seven were Christian, four students were Atheistic/Agnostic, three were Mainline Protestant, two were Historically Black Protestant, and two were Orthodox. The following religious groups were each represented by one student: Muslim, Jehovah's Witness, or having no

religious identity. The academic majors of Introductory Biology students at T.C. students were BIO BS ( $N=19$ ), BIO BA, ( $N=8$ ), BIO ED ( $N=8$ ); General Studies ( $N=4$ ), and Business ( $N=3$ ). The following majors were each represented by one student: Community Health, Computer Science, Drama, Medical Technology, Music, Nursing, Psychology, Social Science, and Undecided. In terms of academic class, three of T.C. responding students were incoming freshmen (0 credit hours), 12 were continuing freshmen (1-30 credit hours), 26 were sophomores (31-60 credit hours), seven were juniors (61-90 credit hours), and four were seniors (91+ credit hours).

Sixty-two Introductory Biology students at TAMU-Textarkana completed the survey. Due to the same discrepancies that occurred at T.C. and DYU, sample sizes between 59 and 62 were recorded for any individual item. Of the 62 students surveyed at TAMUT, 41 were female and 21 were male. The ethnic and racial makeup of these Introductory Biology students was primarily white ( $N=38$ ), followed by Hispanic ( $N=9$ ), African-American ( $N=8$ ), and Asian ( $N=4$ ). The following racial/ethnic groups were each represented by one student: American Indian, multiracial, and Hawaiian/Pacific Islander. In terms of religious identity, 25 of responding TAMUT students were Evangelical Protestant, 12 students were Catholic, seven were Christian, five were Mainline Protestant, three were Atheistic/Agnostic, two were Buddhist, and two were Orthodox. In addition, one student was Muslim, one had no religious identity, and one was undecided about their religion. The academic majors of these A&M-Textarkana Introductory Biology students were BIO BS ( $N=38$ ), Education ( $N=5$ ), Psychology ( $N=3$ ), BIO BA ( $N=2$ ), BIO ED ( $N=2$ ), History ( $N=2$ ), and Nursing ( $N=2$ ). Each of the following majors was represented by one student: Computer Science, General Studies, and Social Science. Of 62 Introductory Biology students at A&M-Textarkana, seven were incoming freshmen (0 credit hours), 24 were continuing freshmen (1-30 credit hours), 21 were sophomores (31-60 credit hours), five were juniors (61-90 credit hours), and five were Seniors (91+ credit hours).

The average overall acceptance score for evolution from surveys results compiled from all three colleges was 69.7 ( $s=16.73$ ,  $N=140$ ) out of a possible 100 points (Table 1). Analyses using the acceptance score were limited to the 140 Introductory Biology students who gave one answer to all 20 statements in the MATE survey. The three survey items that showed the highest acceptance of evolution were: 1) knowing that “*Most scientists accept evolutionary theory to be a scientifically valid theory,*” 2) rejecting that “*The age of the earth is less than 20,000 years*”,

and 3) accepting that “*Organisms existing today are the result of evolutionary processes that have occurred over millions of years*” (Table 1). The three survey items students were most undecided about evolution were: 1) “*With few exceptions, organisms on earth came into existence at about the same time,*” 2) “*The theory of evolution cannot be tested scientifically,*” and 3) “*The theory of evolution cannot be correct since it disagrees with the Biblical account of creation*” (Table 1).

*Table 1.* The mean acceptance score for each item in the 20 item MATE survey. As the item score approaches five, this indicates greater acceptance of evolution. Statements marked with (E) measure acceptance of evolution and statements marked with (C) measure rejection of evolution.

| Survey Item  | Mean | s    | N   |
|--|------|------|-----|
| Modern humans are the product of evolutionary processes that have occurred over millions of years (E)            | 3.5  | 1.36 | 140 |
| Organisms existing today are the result of evolutionary processes that have occurred over millions of years (E)  | 3.7  | 1.30 | 140 |
| The theory of evolution cannot be tested scientifically (C)  | 3.3  | 1.12 | 140 |
| The theory of evolution is based on speculation and not valid scientific observation and testing (C)             | 3.4  | 1.20 | 140 |
| Most scientists accept evolutionary theory to be a scientifically valid theory (E)                               | 3.9  | 0.78 | 140 |
| The available data are unclear as to whether evolution actually occurs (C)                                       | 3.3  | 1.11 | 140 |
| Organisms exist today in essentially the same form in which they always have (C)                                 | 3.5  | 1.26 | 140 |
| There is a significant body of data that supports evolutionary theory (E)  | 3.6  | 1.11 | 140 |
| The age of the earth is less than 20,000 years (C)   | 3.7  | 1.20 | 138 |
| Current evolutionary theory is the result of sound scientific research and methodology (E)                       | 3.4  | 1.05 | 140 |
| Evolution is not a scientifically valid theory (C)   | 3.5  | 1.18 | 140 |
| The age of the earth is at least 4 billion years (E)   | 3.6  | 1.04 | 140 |
| Evolutionary theory generates testable predictions with respect to the characteristics of life (E)               | 3.5  | 1.02 | 140 |
| The theory of evolution cannot be correct since it disagrees with the Biblical account of creation (C)           | 3.3  | 1.36 | 140 |
| Humans exist today in essentially the same form in which they always have (C)                                    | 3.3  | 1.30 | 140 |
| Evolutionary theory is supported by factual historical and laboratory data (E)                                   | 3.4  | 1.07 | 140 |
| Much of the scientific community doubts if evolution occurs (C)  | 3.6  | 1.03 | 140 |
| The theory of evolution brings meaning to the diverse characteristics and behaviors observed in living forms (E) | 3.6  | 1.04 | 140 |
| With few exceptions, organisms on earth came into existence at about the same time (C)                           | 3.1  | 1.11 | 140 |
| Evolution is a scientifically valid theory (E)   | 3.5  | 1.09 | 140 |

\* E - In the acceptance score of evolution: Strongly Agree=5, Agree=4, Undecided=3, Disagree=2, Strongly Disagree=1.

\*\* C - In the rejection score of evolution: Strongly Agree=1, Agree=2, Undecided=3, Disagree=4, Strongly Disagree=5.

The responses from each institution are shown in Tables 2, 3 and 4.



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*Table 2.* The summary of responses (%) to the 20-item MATE survey made by Introductory Biology students at D'Youville College ( $N = 73.4$  students per item with  $s = 1.7$  students). Statements marked with (E) measure acceptance of evolution and statements marked with (C) measure rejection of evolution.

| Survey Item  | Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree |
|--|----------------|-------|-----------|----------|-------------------|
| Modern humans are the product of evolutionary processes that have occurred over millions of years (E)            | 43.2           | 33.8  | 13.5      | 2.7      | 6.8               |
| Organisms existing today are the result of evolutionary processes that have occurred over millions of years (E)  | 44.0           | 40.0  | 10.7      | 1.3      | 4.5               |
| The theory of evolution cannot be tested scientifically (C)  | 4.3            | 20.0  | 30.0      | 31.4     | 14.3              |
| The theory of evolution is based on speculation and not valid scientific observation and testing (C)             | 6.7            | 10.7  | 18.7      | 37.3     | 26.7              |
| Most scientists accept evolutionary theory to be a scientifically valid theory (E)                               | 23.0           | 56.8  | 16.2      | 4.1      | 0                 |
| The available data are unclear as to whether evolution actually occurs (C)                                       | 5.6            | 15.5  | 26.8      | 32.4     | 19.7              |
| Organisms exist today in essentially the same form in which they always have (C)                                 | 8.3            | 12.5  | 11.1      | 40.3     | 27.8              |
| There is a significant body of data that supports evolutionary theory (E)  | 25.3           | 49.3  | 18.7      | 5.3      | 1.3               |
| The age of the earth is less than 20,000 years (C)   | 4.1            | 4.1   | 23.3      | 27.4     | 41.1              |
| Current evolutionary theory is the result of sound scientific research and methodology (E)                       | 24.0           | 41.3  | 25.3      | 6.7      | 2.7               |
| Evolution is not a scientifically valid theory (C)   | 6.6            | 6.6   | 15.8      | 42.1     | 28.9              |
| The age of the earth is at least 4 billion years (E)   | 26.4           | 41.7  | 25.0      | 1.4      | 5.6               |
| Evolutionary theory generates testable predictions with respect to the characteristics of life (E)               | 16.2           | 58.1  | 20.3      | 2.7      | 2.7               |
| The theory of evolution cannot be correct since it disagrees with the Biblical account of creation (C)           | 8.5            | 5.6   | 21.1      | 32.4     | 32.4              |
| Humans exist today in essentially the same form in which they always have (C)                                    | 6.9            | 11.1  | 13.9      | 38.9     | 29.2              |
| Evolutionary theory is supported by factual historical and laboratory data (E)                                   | 16.4           | 54.8  | 19.2      | 8.2      | 1.4               |
| Much of the scientific community doubts if evolution occurs (C)  | 1.3            | 8.0   | 20.0      | 46.7     | 24.0              |
| The theory of evolution brings meaning to the diverse characteristics and behaviors observed in living forms (E) | 14.7           | 66.7  | 8.0       | 6.7      | 4.0               |
| With few exceptions, organisms on earth  | 4.2            | 15.3  | 29.2      | 34.7     | 16.7              |

|  |      |      |      |     |     |
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| came into existence at about the same time (C) |      |      |      |     |     |
| Evolution is a scientifically valid theory (E) | 24.7 | 46.6 | 23.3 | 4.1 | 1.4 |

Table 3. The summary of responses (%) to the 20-item MATE survey made by Introductory Biology students at Texarkana College ( $N = 51.3$  students per item with  $s = 1.0$  students). Statements marked with (E) measure acceptance of evolution and statements marked with (C) measure rejection of evolution.

| Survey Item   | Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree |
|---|----------------|-------|-----------|----------|-------------------|
| Modern humans are the product of evolutionary processes that have occurred over millions of years (E)           | 18.0           | 32.0  | 22.0      | 14.0     | 14.0              |
| Organisms existing today are the result of evolutionary processes that have occurred over millions of years (E) | 17.6           | 41.2  | 15.7      | 13.7     | 11.8              |
| The theory of evolution cannot be tested scientifically (C)   | 15.7           | 5.9   | 35.3      | 33.3     | 9.8               |
| The theory of evolution is based on speculation and not valid scientific observation and testing (C)            | 13.5           | 13.5  | 26.9      | 34.6     | 11.5              |
| Most scientists accept evolutionary theory to be a scientifically valid theory (E)                              | 15.4           | 57.1  | 19.2      | 5.8      | 1.9               |
| The available data are unclear as to whether evolution actually occurs (C)                                      | 8.3            | 18.8  | 29.2      | 35.4     | 8.3               |
| Organisms exist today in essentially the same form in which they always have (C)                                | 7.7            | 9.6   | 19.2      | 46.2     | 17.3              |
| There is a significant body of data that supports evolutionary theory (E)                                       | 9.8            | 39.2  | 31.4      | 7.8      | 11.8              |
| The age of the earth is less than 20,000 years (C)  | 3.9            | 9.8   | 31.4      | 19.6     | 35.3              |
| Current evolutionary theory is the result of sound scientific research and methodology (E)                      | 5.8            | 36.5  | 42.3      | 7.7      | 7.7               |
| Evolution is not a scientifically valid theory (C)  | 9.6            | 21.2  | 32.7      | 25.0     | 11.5              |
| The age of the earth is at least 4 billion years (E)  | 19.6           | 37.3  | 35.3      | 5.9      | 2.0               |
| Evolutionary theory generates testable predictions with respect to the characteristics of life (E)              | 11.5           | 36.5  | 36.5      | 9.6      | 5.8               |
| The theory of evolution cannot be correct since it disagrees with the Biblical account of creation (C)          | 18.0           | 24.0  | 24.0      | 14.0     | 20.0              |
| Humans exist today in essentially the same form in which they always have (C)                                   | 11.5           | 26.9  | 19.2      | 28.8     | 13.5              |
| Evolutionary theory is supported by factual historical and laboratory data (E)                                  | 5.9            | 33.3  | 35.3      | 13.7     | 11.8              |
| Much of the scientific community doubts if evolution occurs (C)   | 5.9            | 17.6  | 31.4      | 27.5     | 17.6              |



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|--|------|------|------|------|------|
| The theory of evolution brings meaning to the diverse characteristics and behaviors observed in living forms (E) | 11.5 | 44.2 | 30.8 | 5.8  | 7.7  |
| With few exceptions, organisms on earth came into existence at about the same time (C)                           | 3.8  | 38.5 | 28.8 | 19.2 | 9.6  |
| Evolution is a scientifically valid theory (E)   | 11.5 | 34.6 | 32.7 | 7.7  | 13.5 |

*Table 4.* The summary of responses (%) to the 20-item MATE survey made by Introductory Biology students at Texas A&M University, Texarkana ( $N = 60.9$  students per item with  $s = 1.0$  students). Statements marked with (E) measure acceptance of evolution and statements marked with (C) measure rejection of evolution.

| Survey Item   | Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree |
|---|----------------|-------|-----------|----------|-------------------|
| Modern humans are the product of evolutionary processes that have occurred over millions of years (E)           | 16.4           | 39.3  | 14.8      | 9.8      | 19.7              |
| Organisms existing today are the result of evolutionary processes that have occurred over millions of years (E) | 25.8           | 40.3  | 6.5       | 8.1      | 19.4              |
| The theory of evolution cannot be tested scientifically (C)   | 3.3            | 13.1  | 37.7      | 29.5     | 16.4              |
| The theory of evolution is based on speculation and not valid scientific observation and testing (C)            | 4.9            | 19.7  | 23.0      | 39.3     | 13.1              |
| Most scientists accept evolutionary theory to be a scientifically valid theory (E)                              | 9.8            | 37.2  | 21.3      | 1.6      | 0.0               |
| The available data are unclear as to whether evolution actually occurs (C)                                      | 3.2            | 30.6  | 24.2      | 29.0     | 12.9              |
| Organisms exist today in essentially the same form in which they always have (C)                                | 11.5           | 13.1  | 13.1      | 44.3     | 18.0              |
| There is a significant body of data that supports evolutionary theory (E)                                       | 21.7           | 35.0  | 25.0      | 16.7     | 1.7               |
| The age of the earth is less than 20,000 years (C)  | 8.5            | 13.6  | 23.7      | 30.5     | 23.7              |
| Current evolutionary theory is the result of sound scientific research and methodology (E)                      | 11.3           | 29.0  | 33.9      | 19.4     | 6.5               |
| Evolution is not a scientifically valid theory (C)  | 4.9            | 16.4  | 27.9      | 36.1     | 14.8              |
| The age of the earth is at least 4 billion years (E)  | 10.2           | 37.3  | 25.4      | 15.3     | 11.9              |
| Evolutionary theory generates testable predictions with respect to the characteristics of life (E)              | 10.0           | 41.7  | 26.7      | 20.9     | 1.7               |
| The theory of evolution cannot be correct since it disagrees with the Biblical account of creation (C)          | 13.1           | 19.7  | 27.9      | 21.3     | 18.0              |

|  |      |      |      |      |      |
|--|------|------|------|------|------|
| Humans exist today in essentially the same form in which they always have (C)                                    | 9.7  | 30.6 | 14.5 | 30.6 | 14.5 |
| Evolutionary theory is supported by factual historical and laboratory data (E)                                   | 13.1 | 34.4 | 27.9 | 21.3 | 3.3  |
| Much of the scientific community doubts if evolution occurs (C)  | 4.9  | 9.8  | 31.1 | 37.7 | 16.4 |
| The theory of evolution brings meaning to the diverse characteristics and behaviors observed in living forms (E) | 16.1 | 40.3 | 25.8 | 11.3 | 6.5  |
| With few exceptions, organisms on earth came into existence at about the same time (C)                           | 6.5  | 29.0 | 35.5 | 24.2 | 4.8  |
| Evolution is a scientifically valid theory (E)   | 10.2 | 40.7 | 28.8 | 13.6 | 6.8  |

One-way ANOVA analysis found that only two of these five demographic variables were significantly associated with an Introductory Biology student’s overall acceptance of evolution. Our analysis indicates that for students at the institutions surveyed a student’s overall acceptance of evolution was dependent on the student’s religious identity ( $12df, F=4.94, p<0.0001$ ). Additionally, student’s overall acceptance of evolution was also dependent on the college (DYC, T.C., or TAMUT) the student was enrolled at ( $2df, F=6.773, p=0.0016$ ).

Fisher’s PLSD found significant differences between the mean overall acceptance of evolution between Atheistic/Agnostic students ( $N=12$ , acceptance score = 85.8,  $s=11.87$ ), and Catholic students ( $N=47$ , acceptance score = 75.4,  $s=13.36$ ), and Christian students ( $N=12$ , acceptance score = 59.3,  $s=10.56$ ), and Evangelical Protestant students ( $N=36$ , acceptance score = 57.8,  $s=16.62$ ), and Mainline Protestant students ( $N=10$ , acceptance score 72.9,  $s=19.84$ ) and Orthodox students ( $N=4$ , acceptance score = 64.8,  $s=7.59$ ). Similarly, Catholic students had a higher acceptance of evolution compared to Christian students and Evangelical Protestant students. Mainline Protestant students had a higher acceptance of evolution than did Christian students and Muslim students ( $N=5$ , acceptance score = 72.8,  $s=12.89$ ) were more accepting of evolution than Evangelical Protestant students.

Fisher’s PLSD also identified that Introductory Biology students at DYC ( $N=51$ , acceptance score =76.1,  $s=15.73$ ) had higher acceptance of evolution than did Introductory Biology students at TC ( $N=43$ , acceptance score = 64.8,  $s=16.20$ ) and Introductory Biology students at TAMUT ( $N=46$ , acceptance score = 66.9,  $s=16.35$ ).

When asked about high school instruction in evolution and self-identification as an

evolutionist or creationist, 63.5% of a pool of 137 responding students thought that creationism should be included in biology classes. In terms of their high school biology experience, seven out of 140 students indicated that only creationism was taught, 57 out of 137 students specified that only evolution was taught, and 59 out of 138 noted that both creationism and evolution were taught. The results of our survey indicate that 64 of 138 students identified themselves as creationist, 64 of 138 students identified themselves as evolutionists, and ten were undecided. Our ANOVA analysis indicated that our student's high school experience with evolution was significantly associated with their MATE acceptance score. Introductory Biology students whose high school biology teacher only taught evolution had greater acceptance of evolution (1df,  $F=4.77$ ,  $p=0.0307$ ). When the student's MATE acceptance score was analyzed by the student's existing identity as a creationist, ANOVA identified a significant difference in the mean acceptance score for both groups (1df,  $F=47.699$ ,  $p<0.0001$ ). The mean acceptance score for the theory of evolution by students identifying as creationists was 60.5 ( $N=34$ ,  $s=16.32$ ). When the student's MATE acceptance score was analyzed by the student's existing identity as an evolutionist, ANOVA identified a significant difference in the mean acceptance score for both groups (1df,  $F=89.141$ ,  $p<0.0001$ ). The mean acceptance score for the theory of evolution by students identifying as evolutionists was 80.9 ( $N=65$ ,  $s=11.34$ ).

### DISCUSSION

By every measure, Introductory Biology students at DYC, T.C., and A&M-Texarkana show diversity. They are an appropriately variable group of students to survey for their acceptance of evolution. We found that the three survey items that showed the highest acceptance of evolution were: 1) knowing that "*Most scientists accept evolutionary theory to be a scientifically valid theory*", 2) rejecting that "*The age of the earth is less than 20,000 years*", and 3) accepting that "*Organisms existing today are the result of evolutionary processes that have occurred over millions of years*" (Table 1). In addition, the three survey items where students were most undecided about evolution were that: 1) "*With few exceptions, organisms on earth came into existence at about the same time*", 2) "*The theory of evolution cannot be tested scientifically*", and 3) "*The theory of evolution cannot be correct since it disagrees with the Biblical account of creation*" (Table 1). Emphasized instruction on the evidence for and against these concepts may promote greater acceptance of evolution by Introductory Biology students; the evidence for highly accepted concepts can be presented as reinforcement. On the other hand, the evidence for

evolutionary concepts that are misunderstood can be presented to remove a barrier to greater acceptance of evolution.

Rutledge & Sadler (2007) stated that moderate acceptance of evolution was indicated by an overall MATE score of 65-76, and high acceptance of evolution was shown by an overall MATE score of 77-88. On average, our student's overall MATE survey score was 69.6 ( $s=16.20$ ,  $N=140$ ) out of a possible 100 points. This average score represents a moderate acceptance of evolution and is consistent with another college in southern U.S. Specifically, the MATE score of students at a college in Mississippi was  $64.9 \pm 13.9$  (Walter et al., 2013). Higher levels of acceptance for the theory of evolution were reported at the University of Wisconsin at LaCrosse (MATE score = 72.5; Abraham, Perez, Downey, Herron, & Meir, 2012), Bowling Green State University (MATE score = 78.2 for majors and 71.3 for non-majors; Partin, Underwood, & Worch, 2013), the Pacific Northwest (MATE = 84.8; Abraham et al., 2012), and the University of South Florida (MATE score = 85.2; Fowler & Zeidler, 2012).

The moderate acceptance of evolution by our students was also indicated by the fact that at the time of this survey, 46% of these students identified themselves as evolutionists and the same percentage of these students identified themselves as creationists. Seven percent of students were undecided on their self-identity as creationists or evolutionists. These results are similar to the finding of Miller, Scott, & Okamoto (2006) who found 38% of people polled in the United States agree with the statement "Human beings, as we know them today, developed from an earlier species of animals," 42% disagreed, and 20% were not sure. Our results are less consistent with the results from a recent Pew Research Center's poll which indicated that 60% of U.S. adults agree that humans and other life have evolved over time, and 33% agree that humans and other life exist in their present form since time began (Pew Research Center, 2013). Despite the divergence of our results with the results from the recent Pew Research Center poll, our results are similar to a recent Associated Press (A.P.) poll. Specifically, a poll commissioned by A.P. of adults in the United States found that 31.9% were very/extremely confident that "Life on Earth, including human beings, evolved through a process of natural selection," 43.3% of U.S. adults surveyed in this poll were "not too/not at all" confident in this statement, and 24.7% were somewhat confident of evolution through natural selection (AP-GfK poll, 2014).

One definitive finding from our study was that a student's acceptance of evolution was

dependent on their religious identity ( $9df, F=3.282, p=0.0024$ ). Though Fisher's PLSD found significant differences between the mean overall acceptance of evolution between a variety of students grouped by religious identity, the interpretation of these comparisons is limited by the fact that all religious groups, except Catholics, were represented by ten or fewer students. However, this outcome is supported by the finding of Cotner, Brooks, & Moore (2010), who found that students' religious views were a significant predictor about their knowledge of evolution and beliefs about the world's origin. The more conservative a student's religious views were, the less likely they were to support that statement that the earth is billions of years old, and the less likely they were to correctly answer knowledge based question about evolution. In addition, the Pew Research Center (2013) also found that evolutionary beliefs differed strongly by religious group. If we compare our students' levels of acceptance by religion, our results are broadly consistent with results published by the Pew Research Center (2013). Specifically, they found that evolution was accepted by 78% of mainline Protestants surveyed, 76% of individuals not affiliated with any religion, 68% of white Catholics, and just 27% of white evangelical Protestants.

Our results indicate that student's overall acceptance of evolution was dependent on the college the student was enrolled at ( $2df, F=6.773, p=0.0016$ ). Specifically, Introductory Biology students at DYC had greater acceptance of evolution than did Introductory Biology students at T.C. and Introductory Biology students at TAMUT. In addition, the acceptance of evolution was equivalent at both Texarkana colleges. This result is consistent with other studies that have found variation among colleges in their reported evolution acceptance scores (Walter et al., 2013; Abraham et al., 2012; Partin et al., 2013; Fowler & Zeidler, 2012). We believe our pattern of college specific acceptance scores, where western New York students have a higher acceptance of evolution than students from northeast Texas, reflects the regional population that each college draws its students from. Heddy & Nadelson (2013) published data on the acceptance of evolution by the state. They indicated that New York ranked fourth highest in the United States in acceptance of evolution, Texas ranked 38<sup>th</sup>, and Arkansas ranked 50<sup>th</sup> (Heddy & Nadelson, 2013). Using the statement "Evolution is the best explanation for the origins of human life on Earth," Heddy & Nadelson scored "complete agreement" in New York at 29.8%, in Texas at 17.0%, and in Arkansas at 8.5%. In this study, the U.S. average acceptance of evolution was 19.5% (Heddy & Nadelson, 2013).

Most interestingly, a student’s high school experience with creationism or evolution had no relation to their MATE acceptance score for evolution. Almost all students came to the class with an existing identity as a creationist or an evolutionist. The mean acceptance score for the theory of evolution by students identifying as creationists was 60.9 ( $N=21$ ,  $s=15.1$ ); this score indicates low acceptance of the theory of evolution. The mean acceptance score for the theory of evolution by students identifying as evolutionists was 79.3 ( $N=48$ ,  $s=11.2$ ); this score indicates high acceptance of the theory of evolution. It remains to be seen if instruction on evolution in Introductory Biology will affect student’s acceptance of evolution, given their existing self-identity as creationists or evolutionists. See Table 5.

*Table 5.* The summary of responses (%) by Introductory Biology students to questions about their high school experience with creationism and evolution, plus their self-perception as a creationist or evolutionist.

| Survey Item  | D’Youville College* |      | Texarkana College** |      | Texas A&M, Texarkana*** |      |
|--|---------------------|------|---------------------|------|-------------------------|------|
|  | Yes                 | No   | Yes                 | No   | Yes                     | No   |
| Creationism or intelligent design should be included in biology courses      | 51.9                | 48.1 | 68.6                | 31.4 | 66.1                    | 33.9 |
| My high school biology teacher taught creationism or intelligent design only | 2.7                 | 97.3 | 11.5                | 88.5 | 3.2                     | 96.8 |
| My high school biology teacher taught evolution only                         | 56.6                | 43.4 | 28.0                | 72.0 | 36.1                    | 63.9 |
| My high school biology teacher taught both evolution and creationism         | 37.3                | 62.7 | 37.3                | 62.7 | 49.2                    | 50.8 |
| I consider myself to be a creationist  | 28.9                | 71.1 | 45.1                | 54.9 | 60.7                    | 39.3 |
| I consider myself to be an evolutionist                                      | 63.2                | 36.8 | 29.4                | 70.6 | 39.3                    | 60.7 |

\* D’Youville College,  $N = 75.8$  students per item with  $s = 0.8$  students

\*\* Texarkana College,  $N = 51.0$  students per item with  $s = 0.6$  students

\*\*\* Texas A&M University, Texarkana;  $N = 60.8$  students per item with  $s = 1.0$  students

Interestingly, without respect to their significantly different levels of acceptance for evolution at their college, students believe that creationism or intelligent design should be included in biology courses (DYC - 51.9% yes; T.C. - 68.6% yes; and TAMUT - 66.1% yes). This view was expressed by both evolutionist and creation students. Similar recommendations have been made by high school students who seek a “balanced treatment,” such that both evolution and creationism are taught in biology courses (see citations in Donnelly, Kazempour, & Amirshokoohi, 2008). What student advocates of balanced treatment for evolution and creationism fail to understand or accept, is that separation of church and state in the United States makes this practice unconstitutional (Moore & Cotner, 2009b). In addition, professional

science societies uniformly recommend that the theory of evolution be taught as the keystone to understanding both what is observed and what is predicted in biology (Moore & Cotner, 2009b). Lastly, students who advocate for balanced treatment in the presentation of evolution and creationism in Introductory Biology often overlook that every religion presents a creation story. Therefore, it is impractical, if not impossible, to simultaneously satisfy the desire of all religious groups without being trapped in a quagmire of contradicting religious beliefs.

Ours is a preliminary study that suggests the utility of online surveys to measure student acceptance of evolution at multiple colleges with regard to demographic variables. This approach produced the most comprehensive study of its kind to date. Our method also lends itself to studies that seek to measure the change in student acceptance after instruction on evolution. In addition, online surveys of students' acceptance of evolution increase the sample size so that ANOVA and Fisher's PLSD test can identify which fundamental demographic variables are most strongly associated with the acceptance of evolution by college students. Lastly, our online survey method can be administered at multiple colleges to determine if suggestive demographic patterns shown by the MATE in this study also exist on a broader and more encompassing scale.

### **CONCLUSION**

The American Association for the Advancement of Science (Bauerle 2011, pg. 12), The National Association of Biology Teachers (NABT, 2011), The National Science Teachers Association (NSTA, 2013), The American Association of University Professors (AAUP, 2008), the United States National Academy of Sciences (NAS, 1999), and many other professional science or science education organizations strongly support and advocate for the inclusion evolution in science curriculum. Despite this support, the average acceptance of evolution in the U.S. is 19.5% (Heddy & Nadelson, 2013). If the theory of evolution is to be effectively taught in higher education curriculum, instructors of biology and the other sciences need to understand the population of students they are teaching, including what their preconceived ideas of evolution are and their overall acceptance or rejection of key concepts associated with evolution. Each student and each student body are unique due to their demographics, personal histories, and a variety of other factors. Equipped with this knowledge regarding current understanding and acceptance of evolution, instructors can fine tune and tailor evolution, biology, and other science lessons to best suit the needs of individual students and classes. Our survey methods provide an efficient means by which educators can gather this information so that they can better understand their



student population, and therefore more effectively teach evolution as the fundamental basis of biology.

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## APPENDIX

Appendix 1. Six items added to the MATE to gather demographic data on responding students.

| <b>Demographic Variables</b>  |
|---|
| Gender: I am _____ (female or male)   |
| My ethnicity is _____ (American Indian and Alaska Native, Asian, African American, Hispanic, Multi-Race, Native Hawaiian and other Pacific Islander, White, and Other)  |
| My religious background is _____ (Atheistic/Agnostic, Buddhist, Catholic, Evangelical Protestant, Hindu, Historically Black, Protestant, Jehovah's Witness, Jewish, Mainline Protestant, Mormon, Muslim, Orthodox, and Other) |
| My academic major is _____ (BIO-BS, BIO-BA, BIO-ED, and Other)  |
| My undergraduate standing is _____ (Freshman, no college credit hours; Freshman, 1-30 credit hours; Sophomore, 31-60 credit hours; Junior, 61-90 credit hours; and Senior, 91+ credit hours)                                  |
| I am a student at _____ (D'Youville College, Texarkana College, Texas A&M University at Texarkana)  |

Appendix 2. The 20 item MATE survey. Statements marked with (E\*) measure acceptance of evolution and statements marked with (C\*\*) measure acceptance of creationism.

| Survey Item   | Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree |
|---|----------------|-------|-----------|----------|-------------------|
| Modern humans are the product of evolutionary processes that have occurred over millions of years (E)           |                |       |           |          |                   |
| Organisms existing today are the result of evolutionary processes that have occurred over millions of years (E) |                |       |           |          |                   |
| The theory of evolution cannot be tested scientifically (C)   |                |       |           |          |                   |
| The theory of evolution is based on speculation and not valid scientific observation and testing (C)            |                |       |           |          |                   |
| Most scientists accept evolutionary theory to be a scientifically valid theory (E)                              |                |       |           |          |                   |
| The available data are unclear as to whether evolution actually occurs (C)                                      |                |       |           |          |                   |
| Organisms exist today in essentially the same form in which they always have (C)                                |                |       |           |          |                   |
| There is a significant body of data that supports evolutionary theory (E)                                       |                |       |           |          |                   |
| The age of the earth is less than 20,000 years (C)  |                |       |           |          |                   |
| Current evolutionary theory is the result of sound scientific research and methodology (E)                      |                |       |           |          |                   |
| Evolution is not a scientifically valid theory (C)  |                |       |           |          |                   |
| The age of the earth is at least 4 billion years (E)  |                |       |           |          |                   |
| Evolutionary theory generates testable  |                |       |           |          |                   |

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|--|--|--|--|--|--|
| predictions with respect to the characteristics of life (E)  |  |  |  |  |  |
| The theory of evolution cannot be correct since it disagrees with the Biblical account of creation (C)           |  |  |  |  |  |
| Humans exist today in essentially the same form in which they always have (C)                                    |  |  |  |  |  |
| Evolutionary theory is supported by factual historical and laboratory data (E)                                   |  |  |  |  |  |
| Much of the scientific community doubts if evolution occurs (C)  |  |  |  |  |  |
| The theory of evolution brings meaning to the diverse characteristics and behaviors observed in living forms (E) |  |  |  |  |  |
| With few exceptions, organisms on earth came into existence at about the same time (C)                           |  |  |  |  |  |
| Evolution is a scientifically valid theory (E)   |  |  |  |  |  |

\* E - In the acceptance score of evolution Strongly Agree=5, Agree=4, Undecided=3, Disagree=2, Strongly Disagree=1.

\*\* C - In the acceptance score of evolution Strongly Agree=1, Agree=2, Undecided=3, Disagree=4, Strongly Disagree=5.

Appendix 3. Questions about the student's high school experience with creationism and evolution and their self-perception as a creationist or evolutionist.

| Survey Item  | Yes | No |
|--|-----|----|
| Creationism or intelligent design should be included in biology courses      |     |    |
| My high school biology teacher taught creationism or intelligent design only |     |    |
| My high school biology teacher taught evolution only                         |     |    |
| My high school biology teacher taught both evolution and creationism         |     |    |
| I consider myself to be a creationist  |     |    |
| I consider myself to be an evolutionist                                      |     |    |