Wernström *et al. Evolution: Education and Outreach* (2025) 18:6
https://doi.org/10.1186/s12052-025-00221-8

Evolution: Education and Outreach

RESEARCH Open Access

Attitudes toward the theory of evolution and its misconceptions in Tromsø, Northern Norway

Joel Vikberg Wernström[1*], Vanessa Molin Paynter[1], Ossian Hagevi[2] and Andreas Altenburger[1]

Abstract

Background Evolution is the core of modern biology, but various misconceptions are persistent companions to the theory. The intuitively appealing but discredited suggestion that organisms innately tend to evolve in a predefined direction still lingers, and remains commonly referenced by biologists, the popular media and even educators in the form of so-called 'evolutionary shorthand'. The flawed logic of goal-oriented evolutionary hypotheses such as orthogenesis and teleology is known to negatively impact students' ability to understand evolution, but may remain widespread among the public even in countries where evolution acceptance is high. We have distributed a questionnaire to explore the attitude of respondents in Tromsø, a town in northern Norway, towards accurate evolutionary statements while also asking whether they agree with common misconceptions related to goal-orientation in evolution and hierarchies in nature.

Results Most of the 307 respondents considered evolution to be the best explanation for the origin of species and the development of life on Earth and agreed also to other accurate statements of current evolutionary theory. Nevertheless, a substantial proportion of respondents agreed to common misconception statements which e.g. synonymised evolution with improvement, reflected the great chain of being, and described evolution as a progressive process that tends to result in higher complexity and intelligence. Respondents' inclination towards such evolutionary misconceptions differed significantly based on education level and occupation, and our correlation matrix visualisation indicates that higher agreement with accurate evolutionary statements is associated with lower agreement with misconceptions. Respondents with a university education or an occupational affiliation with biology, and people between 31 and 50 years of age held the lowest degrees of misconceptions.

Conclusions Our results provide a snapshot of current attitudes to evolution and common misconceptions of the theory of biological evolution in Tromsø. While evolution is widely accepted, a substantial proportion of respondents agree to describe the process as goal-oriented and hierarchical in line with discredited evolutionary concepts such as orthogenesis. Based on our observation of an acceptance-understanding discrepancy and the fact that evolutionary misconceptions are not uncommon among the public in Tromsø, we welcome a wider debate among biology educators in Norway on how to best teach the theory.

Keywords Evolution, Education, Misconceptions, Shorthand, Orthogenesis, Teleology, Norway

*Correspondence:
[1]The Arctic University Museum of Norway, UiT– The Arctic University of Norway, Lars Thørings veg 10, Tromsø 9006, Norway
[2]Krokom Healthcare Centre, Region Jämtland Härjedalen, Genvägen 5B, 835 31 Krokom, Sweden

Introduction

In 1998, legendary rock band Pearl Jam released their fifth studio album, one track of which is titled *Do the Evolution*. An indisputable hit, the song was accompanied in its release by an animated music video which in many ways epitomized the popular view of the process of evolution that had taken shape one and a half centuries after Darwin. The video begins with scenes that depict the dawn of life in the form of single-celled organisms which divide and develop into multicellular life forms, sequentially turning into fish, dinosaurs, mammals, primates, and eventually humans. Like many other popular portrayals of evolution, the video seems to convey the process as progressive and directional, with the next generation of organisms always being more complex, ferocious, and superior to the preceding one as they succeed each other in a natural hierarchy. While this goal-oriented, directional view of evolution is not supported by empirical evidence (Werth 2012; Rigato and Minelli 2013; Werth and Allchin 2020; Schramm and Schmiemann 2019; Johnson et al. 2012; Walker et al. 2024; Ferguson et al. 2022), it was once hotly debated whether organisms really did evolve towards the predefined goal of higher complexity, intelligence, or perfection (in the discredited assemblage of hypotheses collectively referred to as *orthogenesis*) and whether organismal traits could be described as existing for a purpose rather than as consequences of selection (a concept known as *teleology*). Many past scientists who promoted hypotheses of goal-oriented evolution saw a hierarchy in nature, evident from the practice of referring to clades as e.g. "lower plants" or "higher animals" and to organisms as "old", "modern", or "primitive" and "advanced" with the implication of superiority of certain taxa (Eimer 1898; Hitchcock 1840). This use of terminology carried a form of value judgement which is widely regarded as undesirable in current science and education (Padian 2013). However, the past popularity of words invoking a natural hierarchy can be understood in the light of "the great chain of being"– an integral part of the western worldview which since antiquity placed humans on top of the creationary ladder, with progressively simpler beings below them (Bowler 2021; Rigato and Minelli 2013). Carrying on this tradition, a large body of scientific works of the past centuries explicitly elevated certain taxa above others in a supposed reflection of the tendency for evolution to strive for higher complexity and improvement. Prolific authors in the field included John Osborn and his work on 'aristogenesis' (Osborn 1934), Jean-Baptiste Lamarck on the 'perfecting tendency' (Gardiner 1897) and many others, see e.g. (Rieppel 2011; Popov 2018; Ulett 2014; Hitchcock 1840; Kutschera and Niklas 2004). Consistent efforts were also made by proponents of goal-oriented evolution to spread their ideas to wider audiences (Popov 2018). Consequently, some of the evolutionary imagery most familiar to the public (Fig. 1a), such as the apes purposefully and triumphantly turning into humans in the *March of Progress* (Priest 2024; Schramm and Schmiemann 2019) famously depicts an orthogenetic narrative. Although goal-oriented evolution is intuitively attractive (González Galli and Meinardi 2010; Kampourakis et al. 2012; Atran 1998; Werth and Allchin 2020; Werth 2012), it remains unsupported by evidence. Today, biological evolution is widely regarded by scientists and educators as an impersonal consequence of selection processes which act on random variation, without any requirement for subjective human definitions of progress (Johnson et al. 2012). While the philosophical debate around the nature of evolution will surely continue, terminology that evokes a goal-oriented and hierarchical view of evolution is slowly being weeded out of academic biology (Czekanski-Moir and Rundell 2020; Rigato and Minelli 2013).

When evolutionary biologists rejected goal-oriented, progressive evolution as a viable hypothesis, it could be discarded as a misconception of evolutionary theory (MacFadden et al., 2012; Watts 2021). However, misconceptions like these remain widely referenced in the classroom in the form of so-called 'evolutionary shorthand' (hereafter referred to simply as *shorthand*), various orthogenetic-sounding or teleological expressions which attempt to succinctly explain biological concepts. We acknowledge that it can be challenging to explain evolution to pupils and students without occasionally using shorthand (Hammann and Nehm 2020), and such phrasing can have some educational value if used with care (Werth and Shear 2014; Kampourakis 2020). However, if these easy-to-swallow expressions become fixed in the student's mind as valid explanations of evolution, it becomes an educational problem that will negatively impact their ability to understand the theory (Barnes et al. 2017; Legare et al. 2018). During our own educations and careers, we have frequently heard students, colleagues and members of the public misrepresent evolutionary theory and findings in various shorthand ways which evoke goal-orientation or natural hierarchies. Phrases such as "springtails are primitive insects" refers to a sister-group relationship but disregards the fact that springtails are not insects at all (Kjer et al. 2006, 2016). Hearing a student say "jellyfish are lower than crustaceans" immediately brings the great chain of being to mind, and in any case the view fails to align with modern cladistics (Rigato and Minelli 2013; Williams and Ebach 2009; Schramm and Schmiemann 2019) as these animals have simply diverged from a long-lost common ancestor (Laumer et al. 2019; Nosenko et al. 2013). The 'living fossil' trope is also alive and well in the form of shorthand and erroneously (Walker et al. 2024) suggests that morphological change and diversification is

Fig. 1 (**a**) Humorous depiction of famously orthogenetic narrative of human evolution encountered by one of the authors in an outhouse near Tromsø. (**b**) In-person distribution of the questionnaire through a public outreach activity focused on evolution. (**c**) Overview of the 22 questionnaire statements. Statements reflecting widely accepted aspects of evolutionary theory are shaded in green, while statements including common misconceptions related to goal-orientation and natural hierarchies are shaded in pink. Insert shows the phylogeny displayed along with statement 15

inherently good– it echoes in phrases such as "crocodiles are 200 million years old" which disregards the fact that no living species of crocodile existed in the Jurassic (Oaks 2011) and "priapulids have not evolved since the Cambrian" in a gross oversimplification of their suite of plesiomorphic traits (Werth and Shear 2014; Wernström et al. 2023). While certain clades have undoubtably outcompeted others to become prolific in their niches (Qvarnström et al. 2024), off-the-cuff remarks about organisms "dominating" their surroundings can be problematic due to a lack of clear definition for dominance in the context of biology– whether it comes down to clade diversity, abundance or biomass seems arbitrary. The fact that evolution teaching often focuses on a constructive narrative (Espinasa and Espinasa 2008) depicting speciation as desirable (Walker et al. 2024) and gives more attention to gains than losses of traits and functions (such as digestive systems in endoparasites, or eyes in cave-dwelling fish (Johnson et al. 2012) likely contributes to the forming of misconceptions, which are rife even in evolutionary textbooks (Padian 2013). As biologists frequently in contact with both students and the public, we believe that the use of shorthand and continued misrepresentation of evolution in popular media (Ferguson et al. 2022) contributes to keeping misconceptions related to goal-orientation and natural hierarchies widely alive.

In Norway, evolution acceptance is generally high but lags behind that of comparable Nordic countries (Miller et al. 2006), and Norwegian school pupils have previously scored lower than those in the other Nordic countries when asked questions about evolution understanding (Guttersrud and Lie 2009). A comparison of teaching plans in the Nordic countries showed that evolution is introduced later in Norwegian schools than it is in Sweden, Finland and Denmark (Onarheim Martens 2015), and the current Norwegian teaching plans for high school courses in biology do not place extraordinary emphasis on evolution as a core unifying principle. It is possible that a lower emphasis on evolution in Norwegian schools is associated with the comparatively lower

acceptance and understanding of the theory in a Nordic context attested in previous studies (Guttersrud and Lie 2009; Miller et al. 2006). To explore attitudes toward evolutionary theory and its misconceptions is in one of the largest population centres in northern Norway, we designed and distributed a questionnaire on evolution and its common misconceptions (related to goal-orientation and natural hierarchies) in Tromsø. Dominated by industries such as shipping, fishing, aquaculture and tourism, Tromsø is a historic melting pot of Norwegian, Sámi and Kven peoples and a culturally diverse university town (Sætermo and Sollid 2021) with several high-profile government and private research institutions. Consequently, Tromsø provided us with a broad base of respondents as we explored attitudes toward the theory of evolution and its misconceptions.

Materials & methods

Survey design and distribution

We designed and implemented an anonymous questionnaire comprised of 22 statements (S1-S22) as well as information on age, education level, and occupation using the Norwegian online survey service Nettskjema. The questionnaire included accurate evolutionary statements (S1-2, S6, S10, S14, S18) but also presented common evolutionary misconceptions related to goal-orientation and natural hierarchies, which were explicitly orthogenetic (S3, S5, S7-8, S11-12, S15-16, S19-22) or teleological (S4, S9, S13, S17) in nature. In the questionnaire design phase, we were inspired by the Evolution Education Questionnaire on Acceptance and Knowledge framework (Beniermann et al. 2021) and the Measure of Acceptance of the Theory of Evolution instrument (Rutledge and Warden 2010) but did not follow them strictly as we did not seek to measure knowledge levels or collect data on religious beliefs. Responses to the statements were given as five possible levels of agreement ("Fully disagree.", "Somewhat disagree.", "Neither agree nor disagree.", "Somewhat agree.", and "Fully agree."). In the statement design, we considered the available literature of known misconceptions, for instance the fact that novice readers tend to interpret phylogenetic trees with horizontal time axes as depicting a hierarchy with the "most evolved" organisms on the top of the tree (Schramm and Schmiemann 2019). To circumvent the forcing of answers which may result from using only a few rigid options to choose from (McCain and Kampourakis 2018) we also let respondents briefly formulate their own view of evolution in text at the end of the form. As English literacy in Norway is among the highest in the world, the questionnaire statements were written in English to capture as many answers as possible, but text answers at the end of the form could also be provided in other languages which were then translated. The questionnaire with its 22 statements (Fig. 1c) was distributed to the public in Tromsø between March and September 2024 by a variety of means that included mass distribution via e-mail-lists and newsletters, posters in various public venues and workplaces, and through targeted in-person interaction with university students and the public (Fig. 1b).

Ethical considerations

We designed the questionnaire in line with the general guidelines and resources on questionnaire surveys (Hellevik 2019) of the Norwegian National Research Ethics Committees. The questionnaire was anonymous and no personal data (for instance personal names, e-mail addresses or IP numbers) that could link responses to respondents were collected under the definition of the Norwegian personal data act. Both physical and online versions of the form were distributed as to not exclude respondents based on familiarity with e.g. smartphones. Participation in the study was fully voluntary, and no incentives or payment (other than a cup of coffee in some instances) were issued. Age data was collected in brackets instead of discrete numbers to increase anonymity. The questionnaire was distributed to many people from various social settings in Tromsø, which makes it impossible to identify respondents based on background information. Before responding to the questionnaire, participants were presented with our affiliation and what our research aims were, and informed that participation was voluntary. At the end of the questionnaire participants could choose to consent to their answers being used in research, with respondents who did not consent to such use ($n = 5$) being excluded and their answers removed from the dataset. We did not ask for sensitive information such as religious beliefs.

Data analysis

A correlational analysis of the 307 respondents was conducted to explore the relationships between responses to the 22 statements, divided into two categories: E (accurate evolutionary statements) and M (misconceptions invoking orthogenetic or teleological reasoning). Categorical responses were converted into numeric values ("Fully agree." = 5, "Somewhat agree." = 4, "Neither agree nor disagree." = 3, "Somewhat disagree." = 2, "Fully disagree." = 1) from which correlation matrix was calculated and visualised using the R package *corrplot*. In subsequent analyses, levels of agreement with E statements were summed and averaged for each respondent, resulting in a combined value between 1 and 5 which we dubbed the "evolution score". Agreement with M statements was summed and averaged in the same way, resulting in a second numeric variable which we dubbed the "misconception score". The written answers to the questionnaire's final, open-ended question were read by

three of the authors independently and ranked on a scale of 1–5 based on their perceived alignment with evolutionary theory. We cross-compared our rankings and calculated an average score on the 1–5 scale for each answer, where higher values represented a higher degree of agreement with widely accepted aspects of evolutionary theory. The resulting value was then integrated into the evolution score as described above. To investigate relationships between respondents' evolution and misconception scores and their education level and occupational affiliation we performed Kruskal-Wallis tests. When testing the influence of education level, respondents in training or employed as biologists were removed from the analysis to avoid skewing the result towards lower degrees of misconceptions (as all biologists could be assumed to belong to the group with university educations). To investigate the influence of age on misconceptions we fitted a quadratic polynomial regression model of misconception scores against age groups. All analyses were carried out in the software RStudio.

Results

Based on the 307 responses (Supp. File 1) to our questionnaire, we found that (1) acceptance of evolutionary theory among respondents is generally high, but that (2) many agreed with statements containing misconceptions related to goal-oriented evolution and natural hierarchies (Fig. 2). An overwhelming majority of respondents agreed to the theory of evolution being the best explanation for the origin of species and the development of life on Earth (including humans), agreed that fossils provide evidence for evolution by showing that plants and animals have changed over time, and believe in allopatric speciation. Nevertheless, a substantial proportion of respondents were willing to synonymise evolution with improvement, agreed with the statement that humans are more highly evolved than worms, and considered evolution to be a progressive process that tends to result in higher complexity and intelligence.

Our correlation matrix of responses to the 22 statements (Fig. 3) shows a strong tendency of respondents who agree with an accurate evolutionary statement to also agree with the other accurate evolutionary statements. Likewise, we found a corresponding tendency of respondents to agree with other misconception statements if they already agreed to one such statement. Consequently, the correlation matrix visualises a clear dichotomy between agreement with accurate evolutionary statements and agreement with misconception statements related to goal-orientation and hierarchies in nature.

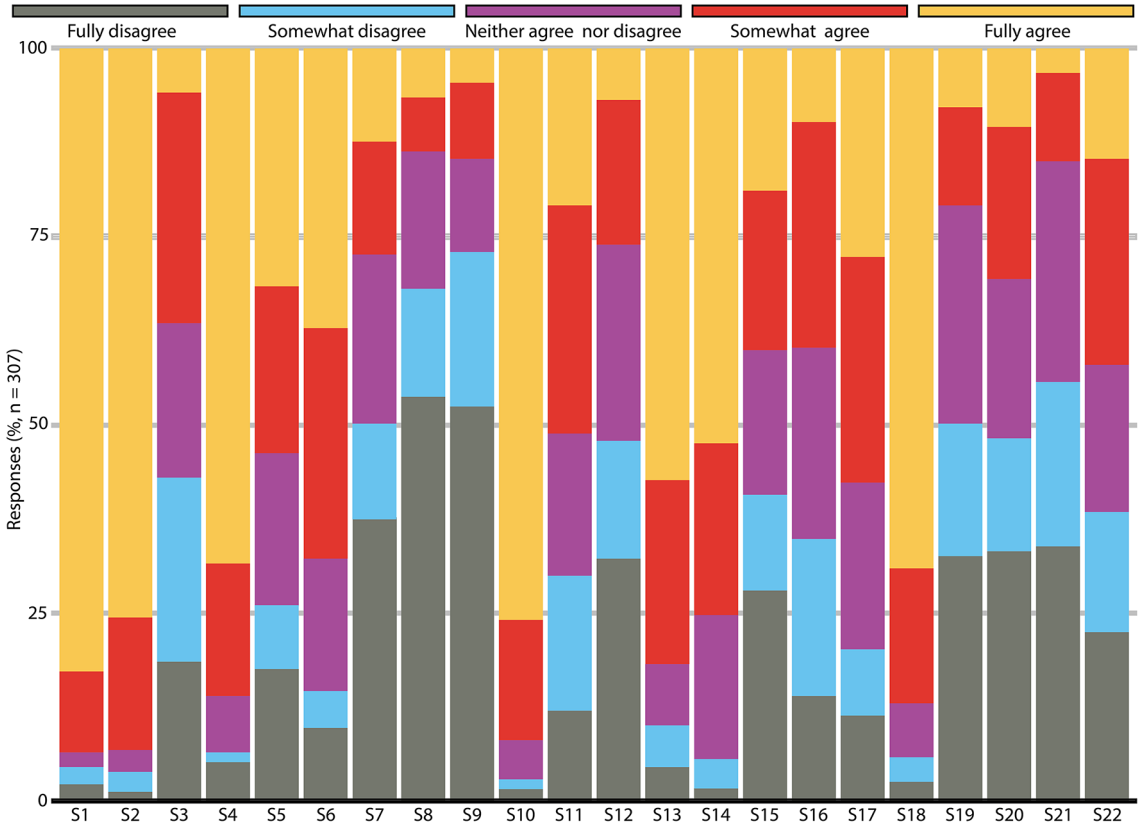

Fig. 2 Percentage-wise distribution of questionnaire responses for the 22 statements

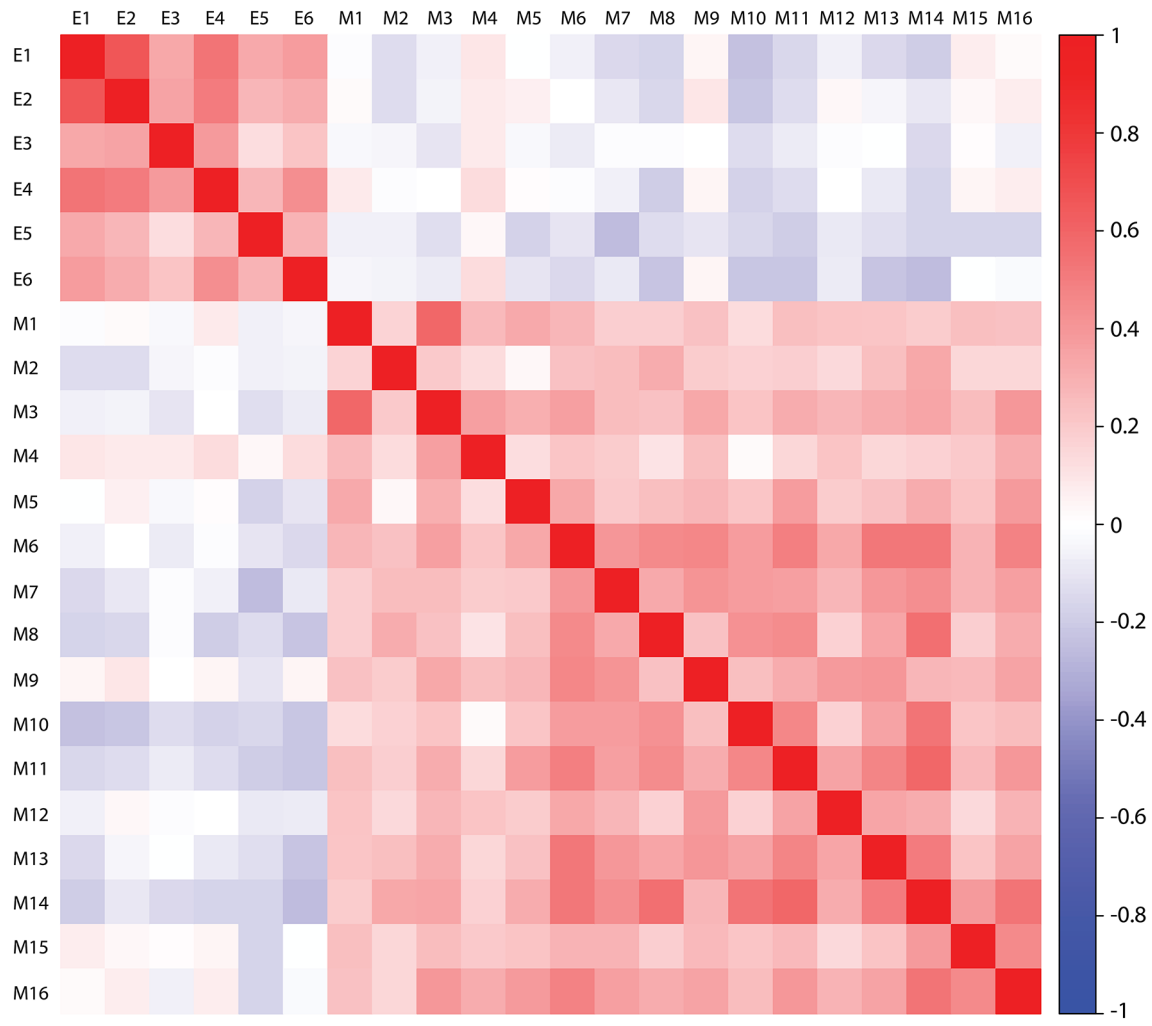

Fig. 3 Correlation matrix of questionnaire respondent's agreement with the statements in categories E (accurate evolutionary statements) and M (misconception statements related to goal-orientation in evolution and natural hierarchies). Red boxes indicate strong correlation between statements, while blue boxes indicate weak correlation

From the data collected, we observe that respondents that are employed or in training as biologists gave answers with significantly lower misconception scores than respondents not affiliated with the biology sphere (Fig. 4a), and our polynomial regression analysis (Fig. 4b) uncovered a weak U-shaped relationship of the respondents' age and their misconception score, demonstrating that a strong command of evolutionary theory was negatively associated with a low and high age. We note that non-biologist respondents with high school, vocational or trade educations were equally inclined to agree with misconceptions, while respondents with university educations were significantly less inclined to do so in comparison to the other groups (Fig. 4c).

We received diverse answers to the questionnaire's final open-ended question, where respondents were free to express their own view of evolution. Most respondents seemed to accept evolution while demonstrating varying degrees of understanding of the theory. Several respondents gave succinct and accurate descriptions of how evolution works (1) or went to great lengths to argue against the obvious orthogenetic and teleological angles of the questionnaire's misconception statements (2).

1. *"The non-random development of new lifeforms based on random variation due to genetic mutations, sexual reproduction and genetic drift. Questionaire have to much emphasis on evolution as a hierarchial deterministic process…".*
2. *"Evolution is the process by which organisms adapt to their environment based on natural selection and mutation of beneficial or superfluous traits. I find the wording of primitive to be highly inappropriate in describing evolution as any organism can have more or less complexity depending on their niche in their environment…".*

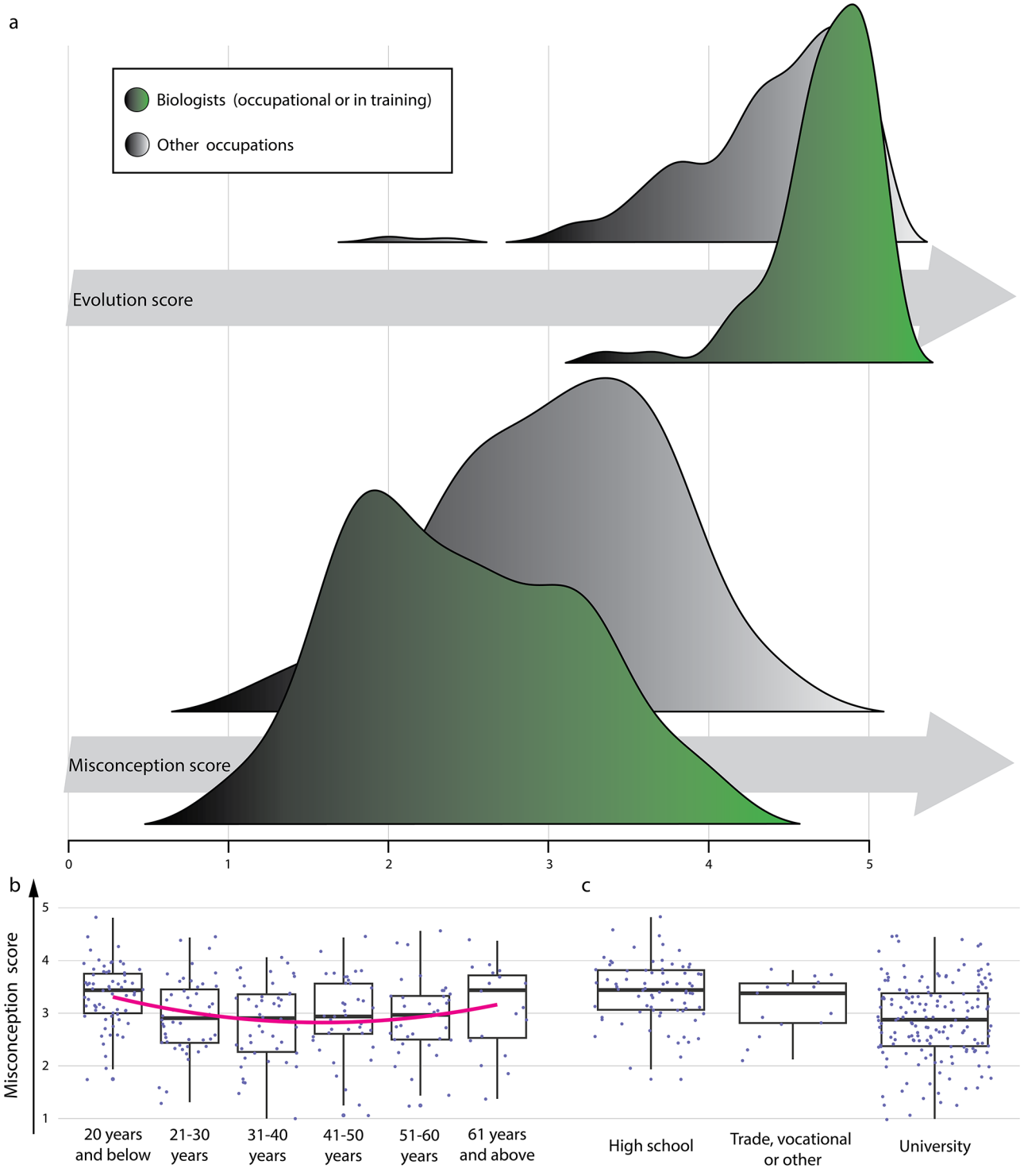

Fig. 4 (**a**) Ridgeline plot of significantly different evolution ($\chi2 = 19.846$, df = 1, $p = 8.394 \cdot 10^{-6}$) and misconception ($\chi2 = 24.147$, df = 1, $p = 8.925 \cdot 10^{-7}$) scores of respondents employed or in training as biologists compared to other occupations. (**b**) Levels of agreement with statements reflecting common misconceptions between age groups with the U-shaped relationship between misconception score and age described by a quadratic polynomial regression model ($R^2 = 6.57\%$, F = 8.825, $p = 1.978 \cdot 10^{-4}$). (**c**) Misconception scores of current or graduated students in high school, trade or vocational education, and university (excluding biologists) also differed significantly ($\chi2 = 30.188$, df = 2, $p = 2.785 \cdot 10^{-7}$)

Other respondents described their religious views, although we did not ask for them, and seemed to reject the theory of evolution outright in favour of creationism (3), some going so far as to argue against the evolution of humans (4).

3. "*God created the heaven and the earth.*"
4. "*Evolution in nature has in my opinion never been proved, since eventual evolutionary changes in each species would take much longer than the life of a human observer… I believe that humans were created by God, since they are so incredibly much more advanced than any other species that I find it unlikely that they are a result of evolution from other species…*".

Several respondents also conveyed explicitly goal-oriented views in their text answer (5), explaining the theory in a way that implied that evolution works towards betterment and higher intelligence, consistent with orthogenesis (6).

5. "*Evolution Are the result of organism desire to always be better than they are now.*"
6. "*Evolution is a change in biological species through thousands of years. It can either improve the determined species, or it can worsen them, improvement are intelligence, functions. What can they do better now than they could thusands- or millions of years.*"

Discussion

Our results indicate that a majority people in Tromsø view evolution as the best explanation for the origin of species and the development of life on Earth, judging by high agreement (>75% fully agree) with the accurate statements S1 and S2 (Fig. 2). This finding is in line with the comparatively high support for the theory of evolution in an international context previously attested in Norway (Miller et al. 2006). Out of the other statements reflecting widely accepted evolutionary theory, the one concerning common ancestry for all organisms was the one to which the least respondents agreed (S6, <50% fully agree). Whether this result reflects disagreement with the substantial evidence which supports the theory of a single common ancestor of life, or whether disagreeing respondents have simply not been exposed to this claim or find e.g. several independent origins more convincing, is an uncertain but intriguing question. Few respondents explicitly rejected evolutionary explanations of biology or embraced creationism in their written responses to the questionnaire (Supp. File 1), a finding which indicates that biology teaching in northern Norway is convincing in terms of evolution acceptance despite the lower emphasis placed on the theory in Norwegian schools as compared to other Nordic countries (Onarheim Martens 2015). Nevertheless, a substantial proportion of respondents not only agreed either strongly or somewhat with orthogenetic (such as S3, >25% fully or somewhat agree) and teleological (such as S4, >75% fully agree or somewhat agree) misconception statements but also provided such reasoning themselves in the questionnaire's final, open-text question. However, other misconception statements e.g. related to the supposed superiority of humans and the *raison d'être* of domesticated animals were strongly rejected by respondents (S8 and S9, >50% fully disagree), demonstrating that responses were context-specific. The misconceptions which received the highest agreement from respondents were teleological rather than orthogenetic in nature, but a majority of respondents also agreed strongly or somewhat to orthogenetic statements such as "humans are more highly evolved than worms" (S5, >50% fully agree or somewhat agree). Statements describing sharks and crocodiles are ancient, primitive and "living fossils" were also agreed to either strongly or somewhat by a substantial proportion of respondents (S11, >50% and S16, >25%). Additionally, many strongly or somewhat agree to the notion that mammals are the dominant organisms on Earth (S12, >25%), in spite of the lack of any biological agreement about the definition of dominance. Supported by information in the written text answers (e.g. quotes 5 and 6), we deem it likely that at least some of the agreement with our misconception statements reflects a worldview influenced by the great chain of being, where evolution is a strictly progressive process. If so, the conclusion is that teaching of evolution in northern Norway has not always succeeded at conveying the theory accurately. It is noteworthy that our correlation matrix (Fig. 3) demonstrates a low level of correlation in agreement between accurate evolutionary statements and misconception statements, meaning that respondents agreeing with one statement category were less prone to also agree with the other category and represents a basic dichotomy within the respondent group, where some were substantially more prone to agree to misconception statements than others. Unsurprisingly, academic biologists and biology students who have been heavily exposed to evolutionary theory scored lower in the misconception metric compared to the other respondents (Fig. 4a) which represented diverse occupational backgrounds, and biologists have likely influenced the observed correlation matrix dichotomy to some degree. Education level also played a role among non-biologists (Fig. 4c), with high school students and graduates having misconception scores on par with respondents enrolled in or graduated from trade and vocational education but higher than those with a university education. This observation could stem from

university students being exposed to science and evolutionary reasoning to a higher degree than non-academics regardless of their subject of study. Respondents at the extreme ends of the age distribution (Fig. 4b) appeared to harbour higher degrees of misconceptions than respondents in the middle of the age range (31–50 year classes having the lowest misconception scores). We suspect that the U-shaped regression results from the fact that teleology and orthogenesis are intuitive to people of young age (Kampourakis et al. 2012), while older respondents could hold views more influenced by e.g. religion– surveys of public evolution acceptance in the U.S have shown a persistent negative association between age and acceptance of evolution (Miller et al. 2022). The high agreement with widely accepted evolutionary statements along with substantial agreement with misconceptions which we observed places emphasis on a well-known fact in evolution teaching - nominal acceptance of the theory does not mean that a person knows its details, or that they understand it well enough to reject discredited concepts such as orthogenesis and teleology. In short, acceptance and knowledge of evolution are different (Beniermann et al. 2021), a discrepancy which has previously been discussed by many other authors (McCain and Kampourakis 2018; Allmon 2011; Barnes et al. 2017). The acceptance-knowledge discrepancy is not necessarily due to a failure of biology teaching, as it could also result from a low personal interest in natural science combined with the lingering impact of the culturally ingrained "great chain of being", the intuitive appeal of orthogenetic explanations, and exposure to evolutionary misconceptions perpetuated by the popular media (Ferguson et al. 2022). However, we cannot reject the possibility that the continued use of shorthand both in education and science media also contributes to perpetuating flawed ideas of how evolution works among students and the public, both in Norway and beyond (Czekanski-Moir and Rundell 2020; Ferguson et al. 2022; Padian 2013). If so, this is unfortunate considering the negative learning outcomes for understanding natural selection and evolution associated with teleological reasoning (Barnes et al. 2017; Legare et al. 2018). Shorthand might make it easier to communicate certain ideas quickly and in an understandable way, but it risks oversimplifying or misrepresenting the nature of evolutionary processes. What is particularly worrying are the potential dangers of the public fundamentally misunderstanding evolution, as the orthogenetic view of evolution where humans purposefully evolved to reign supreme over other organisms is intimately linked to racial supremacy ideologies (Rigato and Minelli 2013; Rieppel 2011; Fischer et al. 2019). Educators thus face the challenge of balancing simplicity and accuracy to ensure that students develop a balanced understanding of evolution and the concept of common descent, where the constructive narrative of functional and trait gains is nuanced with examples of evolutionary loss and simplification.

Limitations

In all, 307 respondents consented to use of their questionnaire responses in our research. Demographic data of Tromsø municipality from the fourth quarter of 2024 attest a population of 79 421 (SSB 2024), of which nearly 0.4% responded to the questionnaire. Based on our conversations with respondents we assume that most were town residents. We did not collect sensitive data on religion or ethnicity and therefore cannot determine whether respondents defined themselves as e.g. Kven, Sámi, or Norwegian or belonging to particular religious groups, but based on our conversations with respondents we believe that responses from a wide variety of affiliations are represented in the dataset. Out of Tromsø municipality's inhabitants, 5367 people (approx. 6.8%) were immigrants from 10 select countries with a large contribution as of the fourth quarter of 2024 and the town has experienced a rapid growth in tourism and international visitors in recent years (Nielsen 2023). Our findings may thus be influenced by responses from visitors to Tromsø or those with an immigrant background to some degree. Therefore, we believe that the results are indicative for larger settlements in northern Norway but would be wary of extending conclusions to e.g. rural segments of the populations or to more narrowly defined religious or ethnical groups.

Conclusions

Our results provide a broad snapshot of current attitudes towards the theory of evolution and its misconceptions in Tromsø. We demonstrate that while the basic concept of biological evolution is widely accepted, a substantial proportion of respondents harboured misconceptions reminiscent of largely discredited goal-oriented evolutionary hypotheses. Respondents with a university education or an occupational affiliation with biology, and people between 31 and 50 years of age held the least degree of such misconceptions, which are kept alive and well by the popular media, in textbooks and in the form of 'evolutionary shorthand' in the classroom. Misconceptions which invoke orthogenetic and teleological reasoning are known to negatively impact students' ability to understand evolution, and we show that they are not uncommon among the public in Tromsø. We therefore welcome a wider debate among biology educators in Norway on e.g. the use of shorthand, and how to best teach the theory.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12052-025-00221-8.

Supplementary Material 1

Acknowledgements
We are grateful towards Siri Asphaug Holmøy, Stine-Mari Lundblad, Linn Kristin Novis and Vanessa Pitusi of The Arctic University Museum of Norway and Anna Rosenberg for help with distributing our questionnaire. We also thank Nils Lindhult of UiT for assistance in organising outreach activities where the questionnaire could be distributed. Additionally, we would like to thank the two anonymous reviewers whose feedback helped us to substantially improve the manuscript.

Author contributions
VMP initiated the discussion on orthogenesis with JVW, who conceived of the study design. JVW and VMP designed the questionnaire with input from AA and OH. OH reviewed and edited the questionnaire methodology. JVW, VMP and AA distributed the questionnaire to respondents. JVW drafted the manuscript and figures which all authors reviewed before they approved of the final version of the manuscript.

Funding
Open access funding provided by UiT The Arctic University of Norway (incl University Hospital of North Norway)
No external funding was used in this study.

Data availability
Data is provided within the supplementary information file.

Declarations

Competing interests
The authors declare no competing interests.

Received: 3 February 2025 / Accepted: 27 March 2025
Published online: 10 April 2025

References

Allmon WD. Why don't people think evolution is true? Implications for teaching, in and out of the classroom. Evolution: Educ Outreach. 2011;4:648–65. https://doi.org/10.1007/s12052-011-0371-0.

Atran S. Folk biology and the anthropology of science: cognitive universals and cultural particulars. Behav Brain Sci. 1998;21:547–69. https://doi.org/10.1017/s0140525x98001277.

Barnes ME, Evans EM, Hazel A, Brownell SE, Nesse RM. Teleological reasoning, not acceptance of evolution, impacts students' ability to learn natural selection. Evolution: Educ Outreach. 2017;10. https://doi.org/10.1186/s12052-017-0070-6.

Beniermann A, Kuschmierz P, Pinxten R, Aivelo T, Bajrami A, Bohlin G, Brennecke JS, Cebesoy UB, Cvetković D, Đorđević M, Dvořáková RM, Futo M, Nicoleta G, Korfiatis K, Lendvai A, Mogias A, Paolucci S, Petersson M, Pietrzak B, Porozovs J, Realdon G, Savković U, Sofonea M, Šorgo A, Stermin AN, Torkar G, Uitto A, Vázquez Ben L, Graf D. Evolution education questionnaire on acceptance and knowledge (EEQ) - Standardised and ready-to-use protocols to measure acceptance of evolution and knowledge about evolution in an international context. Zenodo: Euroscitizen; 2021.

Bowler PJ. From the chain of being to the ladder of creation. Progress unchained: ideas of evolution, human history and the future. Cambridge University Press; 2021. https://doi.org/10.1017/9781108909877.004.

Czekanski-Moir JE, Rundell RJ. Endless forms most stupid, icky, and small: the preponderance of noncharismatic invertebrates as integral to a biologically sound view of life. Ecol Evol. 2020;10:12638–49. https://doi.org/10.1002/ece3.6892

Eimer T. On orthogenesis: and the impotence of natural selection in species formation, Chicago. Open Court Publishing Co. 1898. https://doi.org/10.5962/bhl.title.87978

Espinasa M, Espinasa L. Losing sight of regressive evolution. Evolution: Educ Outreach. 2008;1:509–16. https://doi.org/10.1007/s12052-008-0094-z.

Ferguson DG, Abele J, Palmer S, Willis J, Mcdonald C, Messer C, Lindberg J, Ogden TH, Bailey EG, Jensen JL. Popular media and the bombardment of evolution misconceptions. Evolution: Educ Outreach. 2022;15:19. https://doi.org/10.1186/s12052-022-00179-x.

Fischer MS, Hossfeld JK, Richter S. The Jena declaration. Jena, Haeckel and the question of human races, or, racism creates races. Biol Unserer Zeit. 2019;49:399–402. https://www.uni-jena.de/en/22120/jena-declaration.

Gardiner J. Lamarck and the 'perfecting tendency'. Science. 1897;6:995–7. https://doi.org/10.1126/science.6.157.995.

González Galli LM, Meinardi EN. The role of teleological thinking in learning the darwinian model of evolution. Evolution: Educ Outreach. 2010;4:145–52. https://doi.org/10.1007/s12052-010-0272-7.

Guttersrud Ø, Lie S. Nordiske elevers forståelse av og intresse for biologisk evolusjon. Naturfag. 2009;1:22–4. https://www.naturfag.no/binfil/download2.php?tid=1509891

Hammann M, Nehm RH. Teleology and evolution education: introduction to the special issue. Evolution: Educ Outreach. 2020. https://doi.org/10.1186/s12052-020-00130-y. 13.

Hellevik O. 2019. Questionnaire surveys. National Research Ethics Committees. Accessed 10.05 2024. https://www.forskningsetikk.no/en/resources/the-research-ethics-library/methods/questionnaire-surveys/

Hitchcock E. 1840. Elementary geology, Amherst, Octavo.

Johnson NA, Lahti DC, Blumstein DT. Combating the assumption of evolutionary progress: lessons from the decay and loss of traits. Evolution: Educ Outreach. 2012;5:128–38. https://doi.org/10.1007/s12052-011-0381-y.

Kampourakis K. Students' teleological misconceptions in evolution education: why the underlying design stance, not teleology per Se, is the problem. Evolution: Educ Outreach. 2020;13:1. https://doi.org/10.1186/s12052-019-0116-z.

Kampourakis K, Palaiokrassa E, Papadopoulou M, Pavlidi V, Argyropoulou M. Children's intuitive teleology: shifting the focus of evolution education research. Evolution: Educ Outreach. 2012;5:279–91. https://doi.org/10.1007/s12052-012-0393-2.

Kjer K, Carle F, Litman J, Ware J. A molecular phylogeny of hexapoda. Arthropod Syst Phylogeny. 2006;64:35–44. https://doi.org/10.3897/asp.64.e31642.

Kjer KM, Simon C, Yavorskaya M, Beutel RG. Progress, pitfalls and parallel universes: a history of insect phylogenetics. J Royal Soc Interface. 2016;13. https://doi.org/10.1098/rsif.2016.0363.

Kutschera U, Niklas KJ. The modern theory of biological evolution: an expanded synthesis. Naturwissenschaften. 2004;91:255–76. https://doi.org/10.1007/s00114-004-0515-y.

Laumer CE, Fernandez R, Lemer S, Combosch D, Kocot KM, Riesgo A, Andrade SCS, Sterrer W, Sorensen MV, Giribet G. 2019. Revisiting metazoan phylogeny with genomic sampling of all phyla. Proceedings of the Royal Society B: Biological Sciences 286:20190831. https://doi.org/10.1098/rspb.2019.0831

Legare CH, Opfer JE, Busch JTA, Shtulman A. A field guide for teaching evolution in the social sciences. Evol Hum Behav. 2018;39:257–68. https://doi.org/10.1016/j.evolhumbehav.2018.01.002.

Macfadden BJ, Oviedo LH, Seymour GM, Ellis S. Fossil horses, orthogenesis, and communicating evolution in museums. Evolution: Educ Outreach. 2012;5:29–37. https://doi.org/10.1007/s12052-012-0394-1.

Mccain K, Kampourakis K. Which question do polls about evolution and belief really ask, and why does it matter? Public Underst Sci. 2018;27:2–10. https://doi.org/10.1177/0963662516642726.

Miller JD, Scott EC, Okamoto S. Public acceptance of evolution. Science. 2006;313:765–6. https://doi.org/10.1126/science.1126746.

Miller JD, Scott EC, Ackerman MS, Laspra B, Branch G, Polino C, Huffaker JS. Public acceptance of evolution in the united States, 1985–2020. Public Underst Sci. 2022;31:223–38. https://doi.org/10.1177/09636625211035919.

Nielsen NBV. 2023. International tourism in Tromsø. Graduate Diploma in International Business, Copenhagen Business School. https://research.cbs.dk/files/98726057/1572331_UDG4_Report_Final_Project.pdf

Nosenko T, Schreiber F, Adamska M, Adamski M, Eitel M, Hammel J, Maldonado M, Muller WE, Nickel M, Schierwater B, Vacelet J, Wiens M, Worheide G. Deep metazoan phylogeny: when different genes tell different stories. Mol Phylogenet Evol. 2013;67:223–33. https://doi.org/10.1016/j.ympev.2013.01.010.

Oaks JR. A time-calibrated species tree of crocodylia reveals a recent radiation of the true crocodiles. Evolution. 2011;65:3285–97. https://doi.org/10.1111/j.1558-5646.2011.01373.x.
Onarheim Martens K. 2015. Evolusjonsteorien i laereplaner. Master thesis, Norges teknisk-naturvitenskapelige universitet. http://hdl.handle.net/11250/2436178
Osborn HF. Aristogenesis, the creative principle in the origin of species. Science. 1934;79:41–5. https://doi.org/10.1126/science.79.2038.41.
Padian K. Correcting some common misrepresentations of evolution in textbooks and the media. Evolution: Educ Outreach. 2013. https://doi.org/10.1186/1936-6434-6-11. 6.
Popov I. Orthogenesis versus Darwinism. Cham. 2018;Springer. https://doi.org/10.1007/978-3-319-95144-7_1
Priest G. Hey hey we're the monkeys! An essay review of Gowan Dawson's monkey to man. J Hist Biol. 2024;57:477–84. https://doi.org/10.1007/s10739-024-09786-4.
Qvarnström M, Wernström JV, Wawrzyniak J, Barbacka Z, Pacyna M, Gorecki G, Ziaja A, Jarzynka J, Owocki A, Sulej K, Marynowski T, Pienkowski L, Ahlberg G, P. E., Niedzwiedzki G. Digestive contents and food webs record the advent of dinosaur supremacy. Nature. 2024;636:397–403. https://doi.org/10.1038/s41586-024-08265-4
Rieppel O. Karl Beurlen (1901–1985), nature mysticism, and Aryan paleontology. J Hist Biol. 2011;45:253–99. https://doi.org/10.1007/s10739-011-9283-7
Rigato E, Minelli A. The great chain of being is still here. Evolution: Educ Outreach. 2013. https://doi.org/10.1186/1936-6434-6-18. 6.
Rutledge ML, Warden MA. The development and validation of the measure of acceptance of the theory of evolution instrument. School Sci Math. 2010;99:13–8. https://doi.org/10.1111/j.1949-8594.1999.tb17441.x.
Sætermo M, Sollid H. Reported anguage attitudes among Norwegian speaking in-migrants in Tromsø. Acta Borealia. 2021;38:60–80. https://doi.org/10.1080/08003831.2021.1911209
Schramm T, Schmiemann P. Teleological pitfalls in reading evolutionary trees and ways to avoid them. Evolution: Educ Outreach. 2019;12. https://doi.org/10.1186/s12052-019-0112-3.
SSB. 2024. Innvandrere og norskfødte med innvandrerforeldre. Statistics Norway. https://www.ssb.no/befolkning/innvandrere/statistikk/innvandrere-og-norskfodte-med-innvandrerforeldre. Accessed 01.03 2025.
Ulett MA. 2014. Making the case for orthogenesis: the popularization of definitely directed evolution (1890–1926). Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences 45:124– 32. https://doi.org/10.1016/j.shpsc.2013.11.009
Walker JM, Van Der Heijden ESM, Maulana A, Rueda MN, Nasvall K, Salazar PA, Meyer M, Meier JI. Common misconceptions of speciation. Evolutionary J Linn Soc. 2024. https://doi.org/10.1093/evolinnean/kzae029. 3.
Watts EM. Beyond survival of the fittest: A look at students' misconceptions about natural selection and evolutionary theory. In: Delisle RG, editor. Natural selection. Evolutionary Biology– New perspectives on its development. Cham; 2021. *In*:. https://doi.org/10.1007/978-3-030-65536-5_16
Wernström JV, Slater BJ, Sørensen MV, Crampton D, Altenburger A. 2023. Geometric morphometrics of macro- and meiofaunal priapulid pharyngeal teeth provides a proxy for studying Cambrian tooth taxa. Zoomorphology. https://doi.org/10.1007/s00435-023-00617-4
Werth A. Avoiding the pitfall of progress and associated perils of evolutionary education. Evolution: Educ Outreach. 2012;5:249–65. https://doi.org/10.1007/s12052-012-0417-y.
Werth A, Allchin D. Teleology's long shadow. Evolution: Educ Outreach. 2020. https://doi.org/10.1186/s12052-020-00118-8. 13.
Werth AJ, Shear WA. 2014. The evolutionary truth about living fossils. American Scientist. Research Triangle Park: Sigma Xi, The Scientific Research Society.
Williams DM, Ebach MC. What, exactly, is cladistics? Re-writing the history of systematics and biogeography. Acta Biotheor. 2009;57:249–68. https://doi.org/10.1007/s10441-008-9058-5.

Publisher's note