What is Life—in Everyday Understanding? A Focus Group Study on Lay Perspectives on the Term *Life*

Wolfgang Kerbe*
Johannes Kepler University, Linz
and
Biofaction KG, Vienna

Keywords
Focus groups, naive biology, life, everyday knowledge, synthetic biology

Abstract The philosophical and scientific debate about definitions of *life-as-we-know-it* and its value is very diverse. How do non-biologists characterize these issues? We held focus groups to shed light on the role of the term *life* in laypeople's understanding. Results show that features of early childhood cognition dominate the understanding of the term *life* even in adulthood. Textbook knowledge and definitions derived from specific knowledge systems and beliefs are of minor importance. For an ethical differentiation between life forms the ability to feel and to suffer is seen as the crucial criterion. We conclude that lay perspectives on the concept of life can shape a normative discourse on existing as well as on new life forms in a crucial way. In addition, these perspectives may also strongly influence the expectations towards the *life-as-it-could-be* that is brought forward by the artificial life community. While some concepts like metabolism exist both in scientific and in everyday reasoning as criteria for life, the normative discussion on life is dominated by such ideas as a hierarchical order of living kinds, which emphasize "easy to think" concepts of a moral differentiation. These can also form a basis for the moral standing of artificial life.

1 Introduction

What is life? On the journey from *life-as-we-know-it* to the *life-as-it-could-be*, it is not only the question of the destination that remains open and evolving. What is the starting point? One might argue that biological literature is a solid basis on which to set out for this endeavor. However, societal and ethical implications demand a broader horizon. Common knowledge and non-scientific approaches towards life merge with scientific knowledge and expertise in the public sphere. To be able to engage with the public in a meaningful way, another starting point must be taken into account: lay perspectives on the term *life*.[1]

* Johannes Kepler University, Linz, Austria; Biofaction KG, Vienna; Baumbachstraße 10 A-4020, Linz, Austria. E-mail: wkerbe@gmx.at

1 Talking about life can already be a semantic problem. To define life the way we use it throughout the article we follow the *Merriam Webster Online Dictionary*. According to their definition life is: "a: the quality that distinguishes a vital and functional being from a dead body, b: a principle or force that is considered to underlie the distinctive quality of animate beings or c: an organismic state characterized by capacity for metabolism, growth, reaction to stimuli, and reproduction." (Life. In *Merriam-Webster.com*. Merriam-Webster, n.d. Retrieved 17 Oct. 2014. http://www.merriam-webster.com/dictionary/life.) We have to modify c, because it already gives a list definition of properties of living entities that is characteristic of scientific accounts of life. We therefore suggest: "an organismic state that encompasses certain properties that define a living entity." However, we want to exclude other meanings of life from the discussion (such as life span, biography, or livelihood) that can be found in the dictionary.

 Artificial Life 22: 119–133 (2016) doi:10.1162/ARTL_a_00181

Again: What is life?[2] Some philosophers have argued that this might be an impossible or pointless question to ask [24]. However, in the age of synthetic biology[3] with its several facets of dealing with living organisms, the question gets new meaning. From protocell research to advanced techniques of metabolic engineering, the notion of life as a toolbox gains momentum [5].

In biology, life is defined by traits (or markers): for example, transformation, autopoeisis, metabolism, homeostasis, genome, reproduction, evolution, and interaction with the environment [5]. Other definitions encompass "seven pillars of life": program, improvization, compartmentalization, energy, regeneration, adaptability, and seclusion [19]. Toepfer [30, pp. 164–170] offers a whole historical table of such list definitions, including those by such prominent scientists as Haeckel, Crick, and Mayr; his own approach to the definition of life includes organization, regulation, and evolution. Furthermore, there are non-scientific understandings of life [6], as for instance in philosophic traditions [3, 32] and religions. Synthetic biology as a new emerging technoscience brings new perspectives on life into this discussion.[4]

But what about public opinion, what about commonsense approaches to life? Previous research about living kinds has linked anthropological studies of folk biology and developmental studies in the field of naive biology [13]. Laypeople all over the world, as well as children, categorize objects into four categories: humans, nonhuman animals, plants, and inanimate objects [2]. Furthermore, informal biology relies on intuitive modes of understanding. This encompasses forms of vitalism as conceptual principles of life [15, 17].

The key motivation for investigating naive biology as a case study in developmental psychology is to test assumptions about the development of concepts in children. Authors who specialize in these questions have tried to refine the Piagetian theory of development by showing that processes and products of knowledge construction are domain-specific (e.g., naive psychology, physics, and biology), theory-like even in early childhood, and cognitively and socioculturally constrained [16].

In an earlier study Hatano et al. [12] measured the percentage of children at ages 6, 8, and 10 who are able to classify 16 living and nonliving entities correctly into the following categories: alive, having animal properties, sensory properties, and all-living-things properties. The accuracy is rather high even with 6-year-olds (85% aggregated accuracy across all object and property clusters).

2 Many efforts have been undertaken to answer this question. A few examples from scientific literature are listed here: Schrödinger, E. (1944). *What is life? The physical aspect of the living cell*. Cambridge, UK: Cambridge University Press. Margulis, L., & Sagan, D. (1995). *What is life?* New York: Simon & Schuster. Murphy, M. P., & O'Neill, L. A. J., (1995). *What is life? The next fifty years: Speculations on the future of biology*. Cambridge, UK: Cambridge University Press. Palyi, G., Zucchi, C., & Caglioti, L. (2002). *Fundamentals of life*. Elsevier. Luisi, P. L. (2006). *The emergence of life: From chemical origins to synthetic biology*. Cambridge, UK: Cambridge University Press. Regis, E. (2008). *What is life? Investigating the nature of life in the age of synthetic biology*. Oxford, UK: Oxford University Press. Dabrock, P., Bölker, M., Braun, M., & Ried, J. (Eds.) (2011). *Was ist Leben—im Zeitalter seiner technischen Machbarkeit? Beiträge zur Ethik der synthetischen Biologie*. Freiburg: Karl Alber.

3 Schmidt et al. [29] give the following definition of synthetic biology:

> Synthetic biology is the design and construction of new biological systems not found in nature. Synthetic biology as a scientific label currently includes the following subfields: (A) Engineering DNA-based biological circuits, including but not limited to standardized biological parts; (B) Defining a minimal genome/minimal life (top-down); (C) Constructing protocells, i.e. living cells, from scratch (bottom-up); (D) Creating orthogonal biological systems based on a biochemistry not found in nature, e.g. non-ATGC DNA bases or non-DNA non-RNA nucleic acids, so called XNA (xenonucleic acid) [. . .] Also relevant to synthetic biology is a supporting technology, the chemical synthesis of DNA. [29, p. 1]

4 Depending on the different branches of synthetic biology, different aspects of life are in the focus of consideration. In the engineering approach to construct new biological circuits, the new life is supposed to provide well-designed and -defined metabolic pathways. In the top-down approach the new organisms need merely live, sustained by the environment in the lab. In the bottom-up approach, new life should be similar to natural organisms. Finally, orthogonal biological systems provide life that contains a different code and different amino acids, not to be found in nature [5]. Deplazes-Zemp [5] identifies six modes of dealing with life in synthetic biology: to understand life, to use life, to minimize and optimize life, to vary life, to overcome life, and to design life. This understanding of life is rather novel and corresponds to a toolbox approach to life.

Table 1. Principles of animate-inanimate distinction in infancy [26].

Domain of distinction	Distinction	Categories of distinction
Physical	Onset of motion	Self-propelled versus caused motion
	Line of trajectory	Smooth versus irregular
	Form of causal action	Action at a distance versus action from contact
	Pattern of interaction	Contingent versus non-contingent
	Type of causal role	Agent versus recipient
Psychological	Purpose of action	Goal-directed versus without aim
	Influence of mental states	Intentional versus accidental

Nevertheless, their data show that children have more difficulty with the abstract concept of *alive* than with the more concrete properties of animals, plants, and other living things.

However, Leddon et al. [21] question the methodology of previous studies that used the term *alive* to test children's understanding of biological concepts. In English the word *alive* is ambiguous and includes properties of motion, animistic properties, and animal properties in its meaning. In two experiments they show that using a clearer category like *living thing* helps children to classify living entities in the biological sense in a more successful way.

In addition to the living-nonliving boundary, the classification animate-inanimate has been subject to diverse investigations in developmental psychology. After discussing theories on the emergence of the animate-inanimate distinction in infancy [9, 22, 25, 26], Rakison and Poulin-Dubois [27] offer their own list of principles for this differentiation (Table 1).

The development of distinctions along these lines shows that the animate-inanimate distinction is not an all-or-one phenomenon even with respect to cognitive abilities in infancy. Another aspect of children's judgments about living entities is anthropomorphic reasoning. Rigney and Callanan [28] conclude from their studies on parent-child conversations about animals that anthropomorphism is a learned way of thinking about animals.

Research on adult populations on the living-nonliving and on the animate-inanimate distinction is a rare endeavor. The distinction between animate and inanimate entities is one of the final object distinctions made by Alzheimer's patients [14]. A study on the correlation of paranormal beliefs with confusion of core knowledge domains showed that many undergraduate students do not judge the living-nonliving or the animate-inanimate distinction according to scientific principles [23]. Recent findings in neuropsychology show that there are specific brain domains reserved for the processing of animate and inanimate objects, and even domains that are reserved for animate categories such as similarly behaving animals [4]. This indicates that animate-inanimate distinctions are fundamental elements of human cognition, and "plausibly part of our evolutionary heritage" [1].

Goldberg and Thompson-Schill [10] have focused their research on a later stage of cognitive development as regards the living-nonliving boundary. They have shown that the biological knowledge of adults is rooted in childhood categorization concepts. These are just partially overwritten by conceptual changes in adulthood (e.g., those present in the knowledge of university professors).

In contrast to these mainly experimental research traditions, we have chosen an explorative, qualitative approach to analyze the everyday understanding of life, the living-nonliving boundary, and

people's way of differentiating between major categories of living beings. On the one hand, this approach should contribute to the findings of the previous studies in that it uses an adult sample. On the other hand, it should be a starting point for more quantitative work on adults' concepts of the living as well as for the elaboration of a social representation[5] of life. By choosing such an approach we make ourselves open to any kind of interpretation of living-nonliving boundaries instead of distinguishing a *right* scientific from a *wrong* non-scientific point of view. On the contrary, laypeople's assumptions about life can be seen as embedded in the cultural system of common sense [8]. The principles of commonsense thinking are different from scientific reasoning in that different demands for validity are relevant and that different functions have to be fulfilled (e.g., objectivity versus the ability to communicate). For a differentiated discussion on this matter see Wagner and Hayes [31].

The present study was designed to answer the following questions: (1) What defines the term *life* in the understanding of non-experts? (2) How would laypeople differentiate between major categories of life forms? And (3) how do people make distinctions between life forms with respect to norms and values? We mean to give a first insight into the cognitive and evaluative dimensions of a social representation of the biological term *life*.

2 Method

2.1 Participants

We carried out a total of nine interviews, six focus group discussions, and one larger group discussion in a focus-group-like setting. The total number of participants was 49, including the interviews. The age of the participants ranged from 20 to 70 ($M = 40.5$, $SD = 14.2$).

The interview partners and the participants in one focus group discussion were undergraduate students from Linz University. The other focus group discussions were held with groups with diverse backgrounds: people from a wholesale company, students from a private Catholic university, a group with a strong relation to novel technology, members of a Catholic men's association, and a group with strong links to the esoteric scene. The larger group discussion was organized by a Catholic parish. Participation was compensated at €10 per person-hour.

The groups were selected with respect to three variables: education, supportiveness for technology, and religious belief (Table 2). Education was measured on an ordinal scale from 0 to 7 (see Appendix 1) where 0 meant no formal education and 7 meant a Ph.D. Supportiveness for technology was measured using items from Special Eurobarometer 341 (QB1–QB7, slightly modified; see Appendix 2) on biotechnology [7]. However, the attempt to classify the groups using these items failed due to the large number of "don't know" answers. Religious belief was assessed with the item "Do you believe in God?" on a 5-point Likert scale. The means of the groups are given in Table 2.

While the choice of education as a sampling criterion seems obvious (corresponding to different levels of biological textbook knowledge), the other two criteria need further explication. Both were used simply because the value-laden, normative aspects of the understanding of life were expected to vary across these dimensions.

5 Social representations can be defined by structural features (content), by dynamic characteristics (process), and by their epistemic implications. The first definition regards social representations as individual knowledge systems: Social representations are a "structured, cognitive, affective, evaluative and operative, metaphorical or iconic 'portrayal' of socially relevant phenomena. These can be 'events', 'stimuli' or 'facts' of which individuals are potentially aware and which are shared by other members of the social group. This commonality between people represents a fundamental element of the social identity of the individual" [30, p. 120]. Secondly, when viewed as a process, social representations concern the origin, change, and elaboration of the above-mentioned constructs. Thirdly, social representations function as a kind of macro reduction in cognitive theory, allowing the cross-analysis of different levels (macro-micro relation) [30]. In the tradition of social representations research, different categories of phenomena were the objects of investigation: (a) popularized science, (b) social structures and political events, (c) cultural objects [30].

Table 2. Description of the sample regarding the selection criteria education and religious belief.

Group description	*n*	Education, *Mdn*	Religious belief, *M* (*SD*)
Students (including interviews)	14	4	1.55 (*SD* = 1.57)
Company	7	3	2.29 (*SD* = 0.95)
Esoteric group	6	5.5	2.60 (*SD* = 0.55)
Catholic university	5	6	4.00 (*SD* = 0)
Tech group	6	6	1.17 (*SD* = 1.17)
Catholic parish groups	11	5	3.00 (*SD* = 0.82)

Note: Education is given as the median on an ordinal 8-point scale. Religious belief is given as the mean on a 5-point Likert scale.

2.2 Procedure

Groups were informed, when they were recruited, that they would be involved in a group discussion on synthetic biology. At the beginning of the interviews and focus group sessions, participants were presented with a stone. The interviewer or moderator let them identify the item as a stone and then insisted that the stone was alive. The participants had to argue why they thought whether the stone was alive or not alive (definition of life) and how they would differentiate between different forms of life (category differentiation). Then the participants were confronted with value-laden questions regarding life, namely, why they think killing humans is forbidden in many cultures whereas killing nonhuman organisms is less dramatized. In addition, they were asked what they thought about the manipulation of genetic information within different organisms (moral differentiation). After the discussions and interviews, participants had to fill in a short questionnaire about age, gender, items on supportiveness towards technologies, religious and ideological background, and level of education. Finally, the participants were debriefed.

2.3 Additional Data

In addition to the interview and focus group material, transcripts from a former focus group study [20] were added to the data corpus. In these discussions about newspaper articles on synthetic biology the definition and moral status of life were discussed at some points. This data was not used for analyzing the mere definition of life, but for investigating on the differentiation between life forms.

3 Results

The interviews and discussions (in German) were recorded between March 2012 and February 2013 and transcribed verbatim. (The quotations in this section are translations.) The data corpus consisted of these transcripts and of paraphrased transcripts from the COSY study [20]. With the help of QDA software, Atlas.ti open coding and memo strategies from grounded theory were applied. The units of analysis were thematic units. The resulting codes were structured according to the research questions (definition, category differentiation, and moral differentiation).

3.1 What Defines the Biological Term *Life* in the Lay Perspective?

An overview of the answer to this question is given in Table 3. The categories are discussed in more detail below, in the order of their frequency of occurrence in the data corpus. Furthermore, exemplary quotations from the interviews and discussions are given there.

Table 3. Quotation count of criteria for the definition of life in laypeople's understanding.

Criterion	Number of quotations (number of groups)
Motion	24 (5)
Change	18 (5)
Growth	18 (5)
Metabolism	12 (4)
Soul	8 (3)
Subject to death	7 (4)
Emergence	7 (4)
Consciousness	6 (3)
Inner architecture	6 (2)
Interaction	6 (2)
Respiration	6 (3)
Activity	5 (2)
Energy	4 (2)
Genes	4 (2)
Autonomy	3 (2)
Duration	3 (3)
Transformation of energy	3 (2)
Adaptation	2 (1)
Communication	2 (2)
Gaia	2 (2)
No repetitions	2 (1)
Life force	2 (2)
Evolution	1 (1)
Inner driving force	1 (1)

Note: The quotations were counted in the whole data corpus including interviews and focus groups. Numbers in brackets represent the number of groups (see Table 2) in which the quotations were found.

The ability to move is most frequently and spontaneously given as a defining property of living entities:

Quotation 1. "Because (LAUGHTER) life for me is with, why not, that is a good question, because it obviously cannot even move, because it is rigid, static, yes."

This implies that objects that do not move are not alive (e.g., plants), whereas any moving object would be (e.g., cars or other moving artefacts). However, the absence of motion is a salient property of the stone that was presented to the participants. It would be interesting to see if other objects (a self-propelled car model, a plant, a seed, a flame) would produce similar reactions.

Motion as a characteristic of living entities is a concept that we acquire at a very early stage of development. The fact that this comes spontaneously, in interviews and focus groups, to define life shows that this mode of categorization is not completely overwritten by definitions of life according to the traits learned at school or at university. Moreover, the prototypic life forms that we have in our minds are human beings and animals whose ability to move is obvious to us.

Participants often emphasize that the living thing must be able to move by itself and not by an external force. However, they attribute liveliness to inanimate objects that are moved by the wind or, as the stone, over the course of millions of years. One participant even classified movement on an atomic level as life.

In the esoteric group motion was also mentioned in connection with the presence of an astral body. This presence, they say, can be seen in the animal kingdom. Associating motion with a non-material property could be interpreted as an "essence of motion."

The second fact that people recognize as an important trait is that living things undergo changes.

Quotation 2. "But if there is a change of form, this is actually a life somehow, maybe not in a way, that we can be aware of it, because our senses cannot capture it, because we don't have the time, but if (there is) a change of form, this happens over a long time span, so there must be something that is alive."

The definition by change includes plants in the realm of the living. Participants argue that this change, as well as the above-mentioned motion, must be something intrinsic to the living object. External changes like corrosion or degradation are excluded from this definition. However, some participants see change in general as a trait of living things and therefore ascribe life status to the stone as well. They say that a change of form can happen over a long period of time and hence can be invisible.

Growth and development are also important in laypeople's understanding of life.

Quotation 3. "From my point of view a stone is not alive, because we relate life to, that something develops, that it grows, that it so to speak develops further."

Growth is an aspect of life that preschool children are already familiar with. In fact, some of the participants did not exclude the stone from the group of living entities, because they attribute growth to crystals, mountains, or "mother earth."

The three most prominent definitions of life in the data corpus are motion, change, and growth/development. The two categories growth and change are also closely related to each other. These three aspects have in common that they are perceivable by vision (although sometimes over a longer period of time). Furthermore change, growth, and movement are elements of preschool children's cognition of living kinds [16, 27].

Metabolism is another property of living entities frequently mentioned by the participants.

Quotation 4. "For me there must be some process involved, some sort of metabolism, or whatever."

This metabolism is sometimes described implicitly:

Quotation 5. "Especially bacteria take up something, somehow, and excrete something, I don't know, the stone doesn't do that."

Metabolism is a concept that children seem to acquire at school. It is not as obvious as the concepts above when considering plants, whereas animals and human beings visibly eat and excrete substances.

The notion of a soul for the definition of life did not come up in the Christian groups that would attribute a soul only to human beings. It was mentioned in the student and esoteric groups.

In some cases life was defined as being subject to death. This may seem a simple antonymic definition, but it actually formulates life as a *state*, which a living entity can lose, turning into dead matter.

Although an important criterion for the differentiation between classes of living entities (see below), the possession of consciousness served also as defining motive for life in general. Participants occasionally mentioned that it is hard to tell, in spite of scientific methods, if an object has consciousness or not.

Life was also defined in terms of emergence: Participants said that life is more than the sum of the parts of an organism.

A characteristic described by the interviewees was the inner architecture of organisms (for instance, being composed of cells).

Quotation 6. "Yes you would say that also in biology, that they (single-cell organisms) live, because of their inner architecture."

This is a definition that comes close to modern scientific characterizations of life that are rooted in a mechanistic or materialistic view of life.

According to the participants, living organisms interact with the environment. This can be interpreted as a more general notion, which encompasses metabolism and motion and the more specific term *respiration,* which was also a defining criterion for some participants.

Activity, as a defining criterion for life, can also be seen as an umbrella term for motion, change, metabolism, respiration, and others. It clearly draws the boundary between the living and the stone, which has the outer appearance of being passive and only moved or changed by outer forces.

In spite of the ongoing discussions in the media and the life sciences, the possession of genes was only mentioned in two groups (the student and the tech group).

In two groups the notion of energy was associated with life, meant more in an esoteric than in the physical sense.

Living entities were also described as *autonomous*.

The term *duration* in connection with life means that some participants emphasized the observable time scale in which processes of life happen, in contrast to geological time.

Transformation of energy (in the physical sense), adaptation to the environment, communication, and the ability to evolve were named as further defining elements of life.

In two cases the Gaia hypothesis was mentioned, which attributes the status of life to the whole ecosystem of the planet Earth.

One group declared the absence of repetitions as a property of living systems.

The presence of a life force (*vis vitae*) in living entities was mentioned twice. One participant also attributed a more physical inner driving force to living things.

Comparing the data with biological textbook definitions [5, 19, 30] one can find traits in the latter that are completely absent from everyday understanding. These are processes for the organization of systems, stability, interdependence of parts, autopoeisis, chemical uniqueness, improvisation, compartmentalization, regeneration, and seclusion, to name but a few.

3.1.1 Group-Specific Definitions

The esoteric group was the only group that did not use growth as a defining criterion for life. This group also stated that there is no repetition in living entities, meaning that continuous change connected to individuality is an important characteristic, while it was the only group that did not use mere change as a defining trait. (The absence of repetition implies change, whereas change does not imply the absence of repetition.) People from the Catholic university were the only ones to describe life as a material inner driving force.

Evolution was only mentioned by the tech group. This group had also the highest number of different defining items per participant. Students were the only ones to mention the adaptation to the environment as essential for living beings. The criterion for life that they quoted most often was absent in the discussion of the church parish groups.

We found the lowest diversity of characteristics in the company and the Catholic university groups (6 each), and the highest in the tech group (16) and the student group (18).

3.1.2 Classification of Definitions

Participants' definitions can be further classified in the following categories: traits that are easily perceivable with our senses (*sensory*), traits that are *abstract*, *process*-like concepts, and traits that can mainly be observed using *scientific* apparatus. (See Table 4.) This categorization shows the dominance of easily perceivable traits relative to the other classes of definitions in everyday understanding of the biological term *life*.

3.2 How Do Laypeople Differentiate between Major Categories of Life Forms?

The main criterion of differentiation between major categories (humans, nonhuman animals, plants, microorganisms, and inanimate objects) that participants referred to was consciousness, intelligence, mind, the ability to think, or the possession of a brain.

Quotation 7. "OK. The bird is a being with a brain, with a real distinctive brain so to speak. It directs everything with it. The tree is also a living object, because it changes and changes by itself, but not consciously but simply by environmental influences, weather and seasons. That is the difference: brain and no brain."

Quotation 8. "So I would say, finally everything can be put down to consciousness, and man is in this, if you see it like this, in the highest order, if you like, because he has self-consciousness, because he is self-conscious."

Quotation 9. "That really is for me the possibility to think that distinguishes these two kinds of life (humans, animals) from things."

This may be a representation of anthropomorphizing reasoning that takes human beings as a prototype for life. Nonetheless, the attribution of a consciousness as a trait of living organisms, albeit rather rudimentary when concerning microorganisms, can be found in philosophical literature (e.g., [3]). A consequence is that a basic differentiation between artefacts, plants, animals, and human beings is also possible along these lines.

The second prominent feature for differentiation was inner architecture, the composition of the organisms. Less important criteria were adaptation to the environment, similarity to human beings, language, and the use of tools. In the esoteric group the possession or absence of certain bodies (astral body, mental body) served as classification methodology.

These categorization strategies have in common that they use rather abstract concepts in contrast to the mere definition of life. It is hard to perceive consciousness, inner architecture, adaptation, and astral bodies with the sensory apparatus. Motion, growth, and change, on the other hand, are more directly linked to perceptions, and are therefore less abstract concepts.

3.3 How Do Laypeople Differentiate between Life Forms with Respect to Norms and Values?

The most important trait for normative differentiation between living entities was their ability to have feelings, to feel pain, or to be able to suffer.

Table 4. Classification of participants' definitions.

Criterion	Category
Motion	Sensory
Change	Sensory
Growth	Sensory
Metabolism	Sensory, scientific
Soul	Abstract
Subject to death	Antonym
Emergence	Abstract
Consciousness	Abstract
Inner architecture	Scientific
Interaction	Sensory, scientific
Respiration	Sensory
Activity	Sensory
Energy	Abstract
Genes	Scientific
Autonomy	Abstract, scientific
Duration	Process
Transformation of energy	Scientific
Adaptation	Process
Communication	Sensory, scientific
Gaia	Abstract
No repetitions	Process
Life force	Abstract
Evolution	Abstract, process
Inner driving force	Scientific

Note: Criteria are listed in the order of their frequency (see Table 3).

Quotation 10. "Exactly, but I don't know, if I look at such a thing, at fur farms or the like, then I have pity somehow as a normal human being, or sympathy or something like that because I see that that thing suffers and if I kill another man, then I also see that he suffers. Therefore I would argue like that."

Quotation 11. "Anyway, a mouse, fish, goat, human, they all feel pain. So a stone, if you like, if I try to smash it with an axe, on my opinion it does not feel that. It does not hurt it. It may be a pity because the beautiful stone is broken but in principle it does not feel it. But with living things it is simply that they have feelings. You don't know if that changes their brains, if they have pain, or if they will have any disadvantages in life and that, I think, should not be caused deliberately."

This is again an anthropomorphizing viewpoint that extends human experiences with suffering to animals and plants.

There were two interrelated criteria as regards moral differentiation, namely the survival of man and the food chain. The first was a more anthropocentric argument. Sometimes the two motives intertwined:

Quotation 12. "Because animals have always been in the food chain. We had to kill them to be able to feed ourselves."

The argument of man's place in a food chain reminds one of the old model of the *great chain of being*. The argument of the food chain as well as that of the divine order of the great chain of being assume a hierarchical taxonomic principle. These hierarchical models seem to appeal to a commonsense mechanism of ordering living entities due to an "easily thinkable" principle and also allow for a categorization of organisms under normative aspects.

The visibility of the organisms was also important for the judgment of interference, manipulation, or killing.

Quotation 13. "And with human beings, if I kill a human being, and a plant and a bacterium, [. . .] I cannot even see it. [. . .] It all circles around the question what I can perceive as a human being, and what I cannot perceive."

This visibility is similar to the sensory-perceivable concepts in the lay definitions mentioned above. In addition, the remoteness of something invisible to human beings in the hierarchical concepts of the food chain and the great chain of being is obvious and therefore tends to exclude these entities from ethical considerations.

As has been mentioned above, the notion of consciousness served as a defining trait of living entities and as a general differentiation criterion. However, consciousness or the possession of a brain was also helpful for making ethical differences between life forms.

Quotation 14. "If I copy the material, I do not have that, but so to speak, the more stupid an organism is, the less we care if we interfere with its genome, so in other words this is the case with any kind of bacteria."

For genetic manipulation people differentiated between contained (for instance in laboratories) and uncontained organisms. This stems from a general risk perception of organisms, rather than from their intrinsic value.

There was also the argument that there is a sanctity or value of life for any kind of living organism. Therefore these entities should be seen as morally considerable. This follows the assumptions and belief systems of some Indian and African philosophies [3] and also the general concept of biocentric thinking [11].

The attribution of a soul was important for some groups for moral differentiation. In philosophy this goes back as far as Aristotle and culminates in medieval mysticism. In the participants'

expressions the soul concept varies from an animistic picture that assumes that all living kinds have a soul to a more anthropocentric picture, where human beings alone are in the possession of it.

Finally, participants would also differentiate between classes of living things by their cuteness: You should not kill what you can caress.

4 Conclusions

For the quest to get from the life-as-we-know-it to the life-as-it-could-be, and especially for a rich discourse on such issues, not only within the scientific community, but also with a wider public, several conclusions have to be drawn.

First of all, the normative aspects of life have to be taken into account. In everyday understanding, whatever we do to existing living entities and what new entities should be made, and how they should be treated, normatively depends primarily on the attribution of an ability to suffer. This goes beyond scientific stimulus-response models and consists of a mere everyday assumption about which living kinds can suffer and which cannot. This attribution of an ability to suffer will clearly shape the standing of artificial living entities, too. Although biocentric perspectives widen the range of moral considerations to all living things, the lay groups shared the opinion of some philosophers that suffering is the crucial criterion [11].

Secondly, common sense uses hierarchical models such as the food chain, anthropomorphizing assumptions (a similarity to human beings), and even the great chain of being for structuring the ethical aspects of life. This may lead to an acceptance of altering existing life or creating new life on the level of microorganisms, in contrast to severe objections regarding higher organisms (see also [18]). A question for further research would be, where artificial life would fit into this order. Is similarity to existing entities the key criterion for laypeople's judgments? Are the new entities regarded as mere artefacts, or even regarded as the latest stage of evolution, and valued as such?

Furthermore, a social representation of life or, in other terms, a lay concept emphasizes traits that are easily perceivable with our senses, whereas abstract concepts like soul or consciousness and traits that are only measurable with scientific devices such as genes and a cellular inner architecture are less prominent in the everyday understanding of the living. This is also the case for process-like characteristics such as evolution and adaptation, which are also hard to observe for the non-scientific eye. The consequence of this reduction to the sensory apparatus for the categorization of artificial life forms is that to become "real" for laypersons, the new life forms or the consequences of their existence must be perceivable to them.

However, the structure of the representation of life incorporates scientific as well as non-scientific concepts. This shows on the one hand that engaging the public on issues of life can build on a dialogue along the lines of common concepts such as metabolism or evolution. This can easily be complemented by more scientific education or explanation.

On the other hand, the picture is only complete when non-scientific concepts enter the stage, such as for instance the notion of a soul, or an assumption of an ability to suffer, which heavily influence normative aspects of life. These notions inform the laypersons' normative concepts of how to order the living. Biocentrism or hierarchical models of nature can structure not only how existing life should be treated but also what the status of new life ought to be. The resulting lay theories or concepts are "easy to think" and allow for pragmatic action [31].

Finally, we want to draw conclusions from a more psychological perspective, following the lines of the research tradition in developmental psychology mentioned above. The link between the childhood distinction of living and nonliving entities or of animate and inanimate beings and laypeople's concepts is the aspect of motion. This shows that the understanding of the biological term *life* from early childhood cognition still dominates adults' perception of living entities. Other concepts, such as change and growth, are also already familiar to children below the age of 10.

However, growth and motion can also be found in older biological textbook definitions of life (see also [30, pp. 164–165]). Metabolism, emergence, the ability to evolve, interaction with

the environment, and the possession of genes are more examples of textbook knowledge reproduced by the participants. This shows that childhood cognition merges with knowledge from later school socialization to form the cognitive elements of a social representation of life. With the exception of metabolism, the more modern textbook definitions are scarce within the data corpus.

Although the sample also included Christian and esoteric groups, non-scientific criteria such as soul, energy (force), a life force, or the Gaia hypothesis were not very prominent. Further quantitative studies can clarify the proportions of the distribution of these concepts in the public sphere.

These findings support the results from Goldberg and Thompson-Schill [10]. The scientific textbook knowledge from elementary or high-school education only partly overwrites or complements the categorization regime from early childhood.

Concrete traits, while sufficient for defining life, are not sufficient for a rough classification of living entities, although they are ideal for folk or lay taxonomy of specific species. When talking about general categories of living entities, such as human beings, animals, plants, and sometimes microorganisms, participants referred to more abstract concepts such as consciousness, inner architecture, and astral bodies. The primary criterion, consciousness, can be seen as a sort of anthropomorphizing reasoning.

As our ways of recognizing living entities are so deeply inscribed in our mind, the final test for artificial life, whatever form it may take, may be presenting it to children or laypeople to see how they would position it in relation to the existing tree of life.

This study can only contribute to describing the static aspects of a social representation of life and, with respect to the definition of social representations, only its cognitive and parts of its evaluative dimension. As the notion of a soul or that of energy does not seem to be exclusive for esoteric or Christian groups, new assumptions must be made as regards the group specificity of such definitions.

One limitation of the study is the overrepresentation of more highly educated members of the public. The only group that did not have a highly educated background was that of the wholesale company. This was partly due to the introduction of the discussion in the phase of recruiting participants. The topic of synthetic biology was only interesting for people who could at least associate something with the term or who were not embarrassed to discuss matters they were not familiar with.

Furthermore, the study emphasized contributions by Christian groups. This is due to the assumption that these groups would deal more with ethical questions in the context of life than other groups, and that they would enrich the findings with more extreme positions. These two points might distort the picture when trying to generalize the results with respect to a general public. Further studies in this direction should primarily target the groups that were absent in the present sample, to obtain a real image of the public understanding of life.

We asked about criteria for differentiation between classes of organisms in general. To do this more precisely, the classes should be tested two by two: plant versus inanimate object, animal versus human, and so on. To gain even more precise insights into the positioning of artificial life by laypersons, descriptions of existing state-of-the-art examples—in silico or in vitro—could be taken as stimulus material for the focus group discussions.

Acknowledgment

Wolfgang Kerbe acknowledges the financial support of the project "SYNMOD: Synthetic Biology to Obtain Novel Antibiotics and Optimized Production Systems" through the Austrian Science Fund (FWF) grant no. I490-B12.

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Appendix 1

The education scale was derived from ISCED and from the special properties of the Austrian education system (see also http://www.statistik.at/web_en/statistics/education_culture/formal_education/index.html). The scale had these values: 0 = no formal education, 1 = primary school, 2 = secondary school, 3 = secondary school and vocational training, 4 = secondary school upper level, 5 = bachelor, 6 = master, 7 = Ph.D.

The differentiation between 3 and 4 was made because scientific education is generally more common in the upper level of secondary schools than in vocational training. Therefore, the scale is not identical with the ISCED scale.

Appendix 2

The question was posed as follows: "For each of these areas of technology development, do you think it will have a positive, a negative or no effect on our way of life in the next 20 years?: Solar energy, genetic engineering, nuclear energy, synthetic biology, information technology, nanotechnology, stem cell research."