

- Prologue
- State of Facts
- Consequences
- Lifelong Learning
- Niveaus
- Competencies and commonsense ideas
- Epilogue: Visions

## Prologue Of Quanta and Atoms

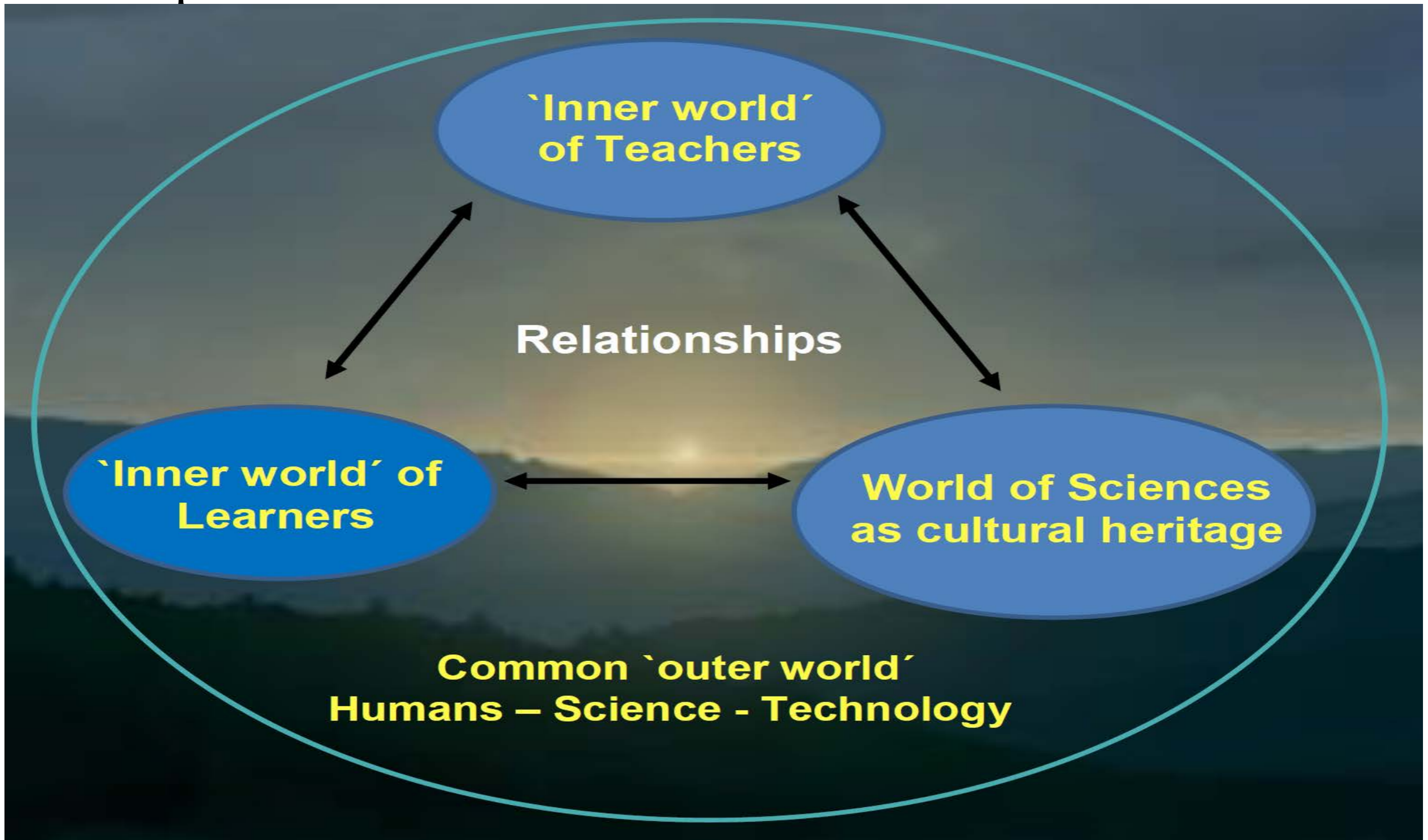
*What do we learn from this?*

- 1. Quanta are positively connoted: the quantum leap means positive progress*
- 2. Atoms are fear possessed: atomic bomb, nuclear power plants*
- 3. She and most adults do not even have a minimum basic understanding of natural sciences (particles, ...)*
- 4. Instead esoteric: vaccination, red vs. green genetic engineering*

## State of Facts

- Education in natural sciences is, just like music, literature etc., part of general education: cultural assets of humanity!
- Knowledge in natural sciences is more urgent than ever (climate change, molecular genetics)
- However, knowledge and competences in natural sciences do only exist rudimentary
- High numbers of students on the lowest level of natural sciences.
- Swing from science: primary school high interest in natural sciences, from 7th grade strongly decreasing, students interested in natural sciences are outcasts.
- Cognitive overload (based on a too early abstraction) leads to resignation with the students.
- For more than 30 years, attempts to increase interest and competences (e.g. Nuffield, PSSC, natural sciences in context) showed little effect.
- Demand for transformative education (understanding, evaluation of natural sciences) is not fulfilled.

# Konsequenzen



## Consequences

Teaching is a relationship process between

- the inner world of the learner
- the inner world of the teacher
- the world of natural sciences
- the outer world: humanity – nature – technology

*J. Hattie: „Visible learning and teaching occurs, when teachers see learning through the eyes of students and help them become their own teachers, constructing ideas and developing conceptual understanding.“*

Consequences: Change of perspective!

- It is not enough to reduce scientific facts skilfully and didactically
- Teaching must be adapted to the cognitive structures, personal experiences and everyday ideas of the learners.
- The learners must be given enough time to speak and reflect about their ideas.
- Abstract concepts and models should only be introduced when learners are capable of understanding. First comes grasping, then technical terms.
- Gradual learning: experiencing a phenomenon, active handling, understanding, modeling and mathematisation.
- Enquiring attitude of learners and teachers: culture of asking questions.

## Lifelong Learning

Key competence 3. [EU 2007]

*Competence in science refers to the ability and willingness to use the body of knowledge and methodology employed to explain the natural world, in order to identify questions and to draw evidence-based conclusions.*

*For science and technology, essential knowledge comprises the basic principles of the natural world, fundamental scientific concepts, principles and methods, technology and technological products and processes, as well as an understanding of the impact of science and technology on the natural world . . . skills . . . attitude*

- However, basic principles / fundamental scientific concepts are not applied.
- The Common framework of reference for the natural sciences fills this gap.

- Which are the basic principles / fundamental scientific concepts?



# Lifelong Learning

- Process-related competences
- Content-related competences: interdisciplinary
  - Nature of science: cultural meaning
  - Nature, humanity, technology: climate problems
  - Senses: perception and measurement
- Biology
  - Evolution: to explain history of nature on the basis of natural sciences
  - Organism: What health and disease mean
  - Relationship of human beings and nature: to form and preserve the environment
- Chemistry
  - Matter: How properties, structure and use of substances are connected
  - Chemical reactions: What the statement means „a new substance is created“
- Physics
  - Matter: From the very big and very small
  - Theory: Make Nature predictable
  - Energy: The supply of electrical energy in everyday life

# Niveaus

<b>A1</b>	<b>A2</b>	<b>B1</b>	<b>B1+</b>	<b>B2</b>
<p><b>Experience of and dealing with phenomena in nature and technology</b></p>	<p><b>Proper perception and personal interpretation when dealing with phenomena in nature and technology</b></p>	<p><b>Knowledge and application of basic scientific concepts</b></p>	<p><b>Being familiar with the central concepts and ideas of natural sciences as well as applying them independently and reflecting on them</b></p>	<p><b>Being familiar with central concepts and theories of natural sciences, reflecting on and evaluating them independently</b></p>

## Livelong Learning

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## Nature of science: cultural meaning - common sense ideas -

A1

*Technical progress is always good.*

*Technical progress destroys the environment.*

A2

*Technical advances are purely random discoveries.*

B1

*Scientific statements are always true.*

*Natural science and technology are the same.*

*Natural science describes reality as it is.*

B1+

*Natural science is independent of historical and social conditions.*

*Natural science statements are timeless.*

B2

*Scientific findings affect technical progress, but not vice versa.*

*Scientific theories represent secured knowledge.*

*The natural sciences provide the only source of knowledge.*

*Researchers work like hermits.*

*Today's ideas about the natural sciences will not need to be revised in the future.*

*Natural sciences are an achievement of the Western world.*

## Nature of science: cultural meaning

A1

- can give examples from the world around him/her of changes from the past to today, which are due to natural science and technology.

*Technical progress is always good.*

*Technical progress destroys the environment.*

- can imaginatively outline possible changes in the future.

A2

*Technical advances are purely random discoveries.*

- can illustrate examples of technical developments in a proper, age-appropriate everyday language.

B1

*Scientific statements are always true.*

- can show simple examples of how scientific knowledge has been historically developed.

*Natural science and technology are the same.*

- can describe examples of technical applications which are based on scientific findings.

- can outline the lives of selected researchers in a historical context.

*Natural science describes reality as it is.*

- can present an example showing that scientific descriptions often oversimplify.

B1+

- can describe examples of technical applications which are based on technological use of scientific findings

*Natural science is independent of historical and social conditions.*

- can put the lives and achievements of selected researchers into a historical context.

*Natural science statements are timeless.*

- can explain how scientific descriptions, models and laws have been changed.

B2

- can present selected examples of how scientific theories were historically developed.

*Scientific findings affect technical progress, but not vice versa.*

- can describe examples of how scientific and technical knowledge influence each other.

*Scientific theories represent secured knowledge.*

*The natural sciences provide the only source of knowledge.*

- can describe ways of gaining knowledge in the natural sciences, their hypothetical character and their limits.

*Researchers work like hermits.*

- can outline social structures that exist within historical and current scientific research.

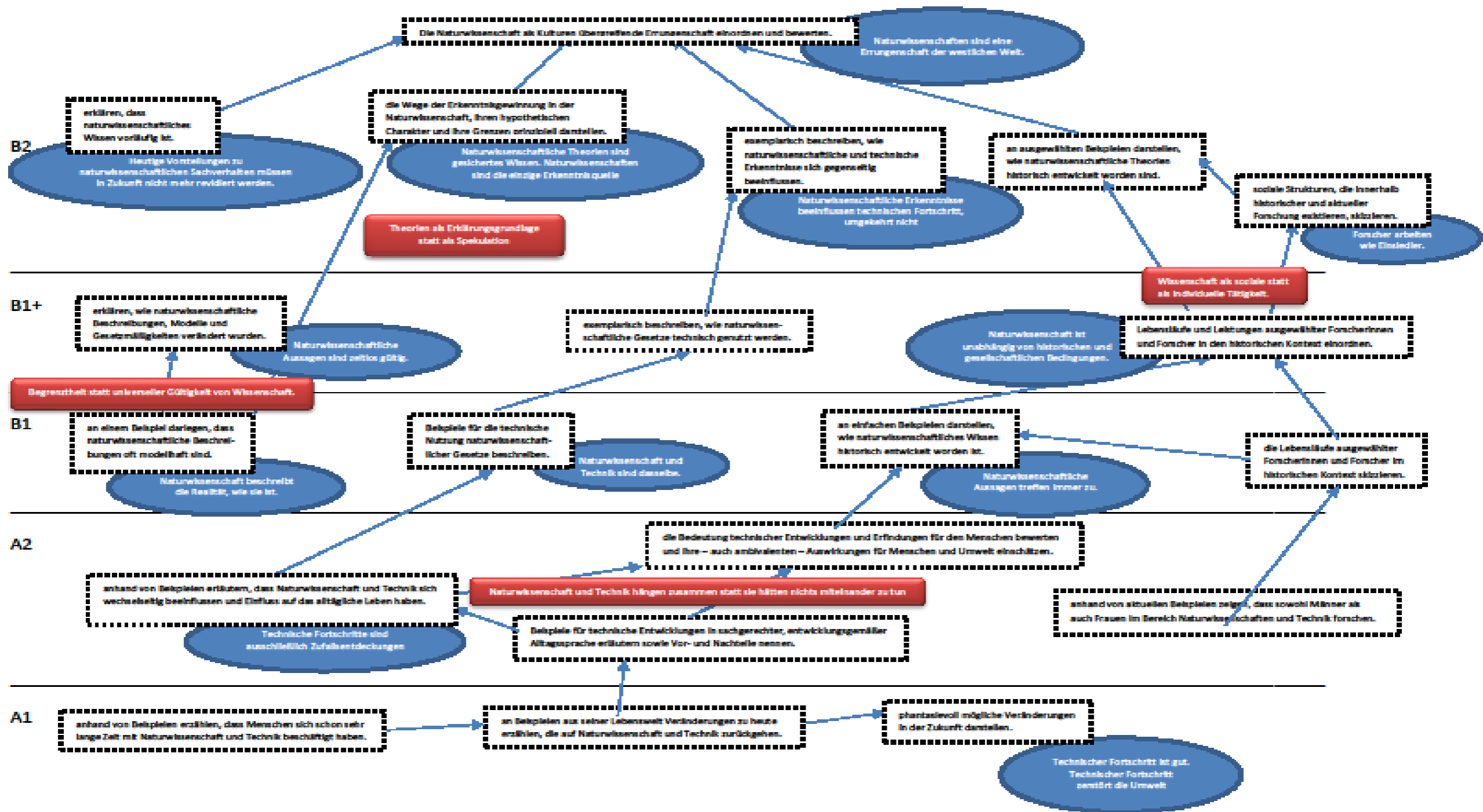
*Today's ideas about the natural sciences will not need to be revised in the future.*

- can explain that scientific knowledge is provisional.

*Natural sciences are an achievement of the Western world.*

- can classify and evaluate science as a cross-cultural achievement.

## Lernlinien: Nature of science (Kompetenzen-Alltagsvorstellungen-Lernhürden)



## Teaching with commonsense ideas

**Linking:** An aspect of commonsense idea is tracked down which corresponds with a technical aspect and therefore provides a starting point from which it is possible to arrive at technically appropriate ideas

**Supplement by a different angle (change of perspective):** The point of view on which the commonsense idea is based is supplemented by a new perspective which revises the commonsense idea (lets it appear in a new light)

**Contrast:** The scientific concept is clearly contrasted with the commonsense idea as an alternative. This procedure can lead to a cognitive conflict.

**Bridge:** Occasionally, preconceptions even offer the chance to arrive at technically more appropriate solutions, sometimes even recognize technical defects.

This type of education in the area of natural sciences requires time. It therefore demands the focus on fundamental examples on the basis of which the learners recognize elementary relationships and principles and achieve insights.



# Lifelong Learning

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## Evolution: to explain history of nature on the basis of natural sciences

### - Common sense ideas -

A2 Humans and dinosaurs lived at the same time.

Inheritance of body parts and their properties.

B1 Today living species are ancestors of the evolved species. Monkeys are ancestors of humans.

Kinship means similarity.

Living things adapt intentionally / purposefully to the environment. Evolution means higher development.

Environment unilaterally determines the living beings.

Living things are passively adapted to their environment.

B1+ Mutations are always harmful.

Adaptation is deliberate and purposeful.

Living things are perfectly adapted.

B2 Evolution is „only“ a theory.

Species is a uniform type of living things: All individuals are the same. Species change like an individual: All species members change at the same time and similarly.

In a constant environment there is no evolution.

„Theories“ are non-binding ways of thinking.

Evolution and religious beliefs contradict each other.

There are human races. Human races are different in their nature.

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## Evolution: to explain history of nature on the basis of natural science

A1

- can name living things from the history of the earth.
- can name animals in their habitat and describe the relationship with their way of life.

A2

- can explain that living things have emerged one after the other.

Humans and dinosaurs lived at the same time.

- can explain inheritance using simple examples.

Inheritance of body parts and their properties.

B1

- can describe the relationship of the living things as ancestry of common ancestors.

Today living species are ancestors of the evolved species. Monkeys are ancestors of humans.

- can describe the history and relationship of living things.

Kinship means similarity.

- can explain the change and the adaptability of populations to different living conditions.

Living things adapt intentionally / purposefully to the environment. Evolution means higher development.

- can explain: Living things influence and shape their environment and are conversely influenced by it.

Environment unilaterally determines the living beings. Living things are passively adapted to their environment.

## Evolution: to explain history of nature on the basis of natural sciences

B1

- can describe how the Earth has been transformed by living things throughout its history.

Living things are passively adapted to their environment.

B1+

- can name mutations and recombination as causes of variability.

Mutations are always harmful.

- can explain adaptation as result of mutation, recombination and selection.

Adaptation is deliberate and purposeful.

- can state that adaptation is never perfect.

Living things are perfectly adapted.

- can cite genetic arguments against racism.

B2

- can explain evolution as scientifically explained phenomenon.

Evolution is „only“ a theory.

- can weigh different species concepts against each other and define speciation based on genetic isolation of populations.

Species is a uniform type of living things: All individuals are the same. Species change like an individual: All species members change at the same time and similarly.

## Evolution: to explain history of nature on the basis of natural science

B2

- can explain to what extent co-evolution is a source of ongoing evolution.

In a constant environment there is no evolution.

- can apply evolutionary theory to different areas of biology.
- can explain the role of theories in the natural sciences using evolutionary theory.

„Theories“ are non-binding ways of thinking.

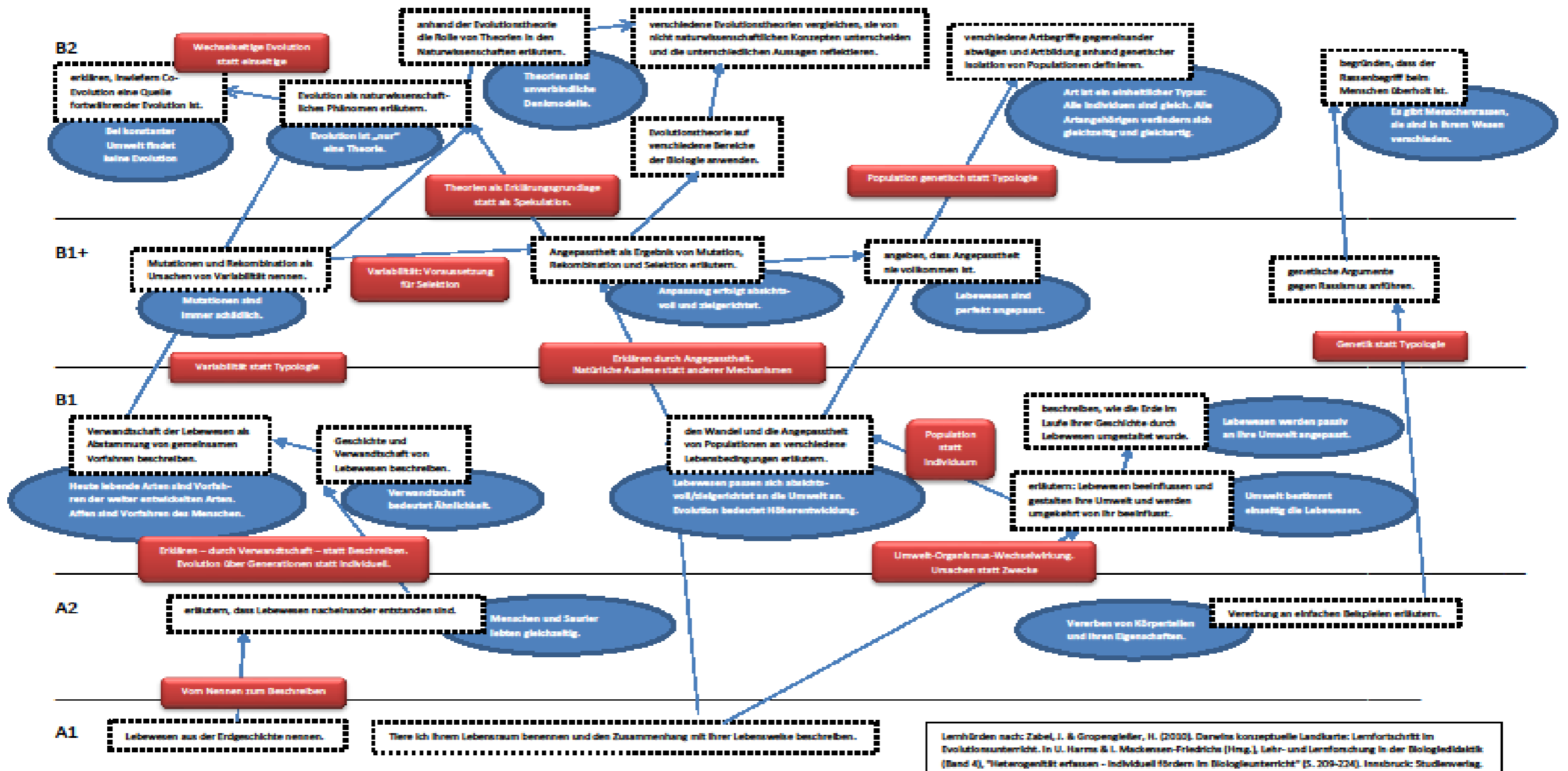
- can compare different evolutionary theories, distinguish them from non-scientific concepts, and reflect the different statements.

Evolution and religious beliefs contradict each other.

- can justify that the concept of race in humans is outdated.

There are human races. Human races are different in their nature.

## Lernlinien: Evolution – Naturgeschichte naturwissenschaftlich erklären (Kompetenzen-Alltagsvorstellungen-Lernhürden)



Lernhürden nach: Zabel, J. & Gropengeller, H. (2020). Darwins konzeptuelle Landkarte: Lernfortschritt im Evolutionsunterricht. In U. Harms & I. Meckensen-Friedrichs (Hrsg.), Lehr- und Lernforschung in der Biologiedidaktik (Band 4), "Heterogenität erfassen - Individual fördern im Biologieunterricht" (S. 209-224). Innsbruck: Studienverlag.

## Epilogue: Visions

**It cannot be accepted that in a country with hardly any natural resources scientific education remains on such a modest level!**

Analogy: The Common European Framework of Reference for Languages has clearly had a positive influence on the culture and the results of language acquisition in school. The Common Framework of Reference for the Natural Sciences is a comparable initiative.

- More education by means of less but well-chosen contents!
- Changing the attitudes of teachers through training
- Curricula reforms: minimum standards based on common sense ideas
- Certificates of training in natural sciences with the help of tasks
- Europeanization of the Common Framework of Reference
- Common Framework of Reference also for computer sciences, technology, geography, all MINT/STEM-subjects

Thank you very much for your attention!