



Physics Education 2.0

Development of a New Teaching
Model based on Particle Physics

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Overview

1. Theoretical framework
2. Model conception
3. Status quo



1. Theoretical framework

Rapid development of particle physics in the last 100+ years

Throughout Europe: problematic integration of particle physics in curricula

Opportunity to embed fundamental principles within the curriculum

1. Theoretical framework

concept development

Constructivist approach

Exploration of the student perspective

STCSE - Students' and Teachers' Conceptions and Science Education

<http://www.ipn.uni-kiel.de/aktuell/stcse/stcse.html>

#	Entry...	Author	Title	Year	Journal
1	Article	Andersson	Pupils' Conceptions of Matter and its Transformations (age...	1990	Studies in Sci...
2	Article	Boz	Turkish Pupils' Conceptions of the Particulate Nature of Ma...	2006	Journal of Sci...
3	Article	Fischer and Breuer	Misconceptions as indispensable steps toward an adequat...	1993	Third Miscon...
4	Article	Gomez et al.	Students' ideas on conservation of matter: Effects of expert...	1995	Science Educ...
5	Article	Harrison and Treagust	Secondary students' mental models of atoms and molecule...	1996	Science Educ...
6	Article	Kalkanis et al.	An instructional model for a radical conceptual change tow...	2003	Science Educ...
7	Article	Meheut et al.	Pupils' (11 - 12 year olds) conceptions of combustion	1985	European Jo...
8	Article	Novick and Nussbaum	Pupils' understanding of the particulate nature of matter: A...	1981	Science Educ...
9	Article	Ozmen	Turkish primary students' conceptions about the particulat...	2011	International...
10	Article	Renstroem	Pupils conceptions of matter. A phenomenographic approa...	1987	Proceedings...
11	Article	Snir et al.	Linking phenomena with competing underlying models: A s...	2003	Science Educ...
12	Article	Stavy	Children's Ideas About Matter	1991	School Scienc...
13	Article	de Vos and Verdonk	The particulate nature of matter in science education and i...	1996	Journal of Re...
14	Article	Windschitl et al.	Beyond the scientific method: Model-based inquiry as a ne...	2008	Science Educ...
15	Article	Yair and Yair	"Everything comes to an end": An intuitive rule in physics an...	2004	Science Educ...
16	Techreport	Dow et al.	Pupils' Concepts of Gases, Liquids and Solids	1978	
17	Unpublis...	Duit	Bibliography - STCSE		
18	Unpublis...	Johnson	Symposium: Teaching and Learning the Particle Model		
19	Article	diSessa	A bird's-eye view of the "pieces" vs. "coherence" controvers...	2008	S. Vosniadou...
20	Article	Arzi and White	Change in Teachers' Knowledge of Subject Matter: A 17-Y...	2007	Science Educ...
21	Article	Baalmann et al.	Schülervorstellungen zu Prozessen der Anpassung - Ergeb...	2004	Zeitschrift für...
22	Article	Christensen and Fensham	Risk, Uncertainty and Complexity in Science Education	2012	Second Inter...
23	Article	Deng	The distinction between key ideas in teaching school physic...	2001	Science Educ...
24	Article	Dickinson	The development of a concept of material kind	1987	Science Educ...
25	Article	Duit	Schülervorstellungen und Lernen von Physik	2004	PIKO-Brief
26	Article	Duit	The constructivist view in science education - what it has to...	1996	Investigações...
27	Article	Duit and Treagust	Conceptual change: A powerful framework for improving sc...	2003	International...
28	Article	Fischer et al.	Fachdidaktische Unterrichtsforschung - Unterrichtsmodelle...	2010	Zeitschrift für...
29	Article	Flick	Where concepts meet percepts: Stimulating analogical thou...	1991	Science Educ...
30	Article	Geddis et al.	Transforming content knowledge: Learning to teach about i...	1993	Science Educ...
31	Article	Haagen-Schützenhöfer et al.	Fremdsprachiger Physikunterricht: Fremdsprachlicher Mehr...	2011	Zeitschrift für...
32	Article	Haagen-Schützenhöfer et al.	Akzeptanzbefragung zu Optikunterrichtsmaterialien	2012	Gesellschaft...
33	Article	Harrison and Treagust	Learning about atoms, molecules, and chemical bonds: A c...	2000	Science Educ...
34	Article	Härtig et al.	Sind Fachsprache und Fachwissen bezogen auf Physik unte...	2012	Zeitschrift für...
35	Article	Hobson	There are no particles, there are only fields	2013	American Jou...
36	Article	Jung	Probing Acceptance, A Technique for Investigating Learning...	1992	R. Duit, F. G...
37	Article	Karsten et al.	Planeten, Wolken oder schwarze Kisten? Wie können wir At...	2011	Physik Journ...
38	Article	Kattmann	Lernen mit anthropomorphen Vorstellungen? Ergebnisse...	2005	Zeitschrift für...



1. Theoretical framework

concept development

„[...] there are still a remarkable number of studies on students' learning in science that primarily investigate such students' conceptions at the content level. Since the middle of the 1980s investigations of students' conceptions at meta-levels, namely conceptions of the nature of science and views of learning (i.e., meta-cognitive conceptions) also have been given considerable attention.” **Duit und Treagust (2003)**



1. Theoretical framework

concept development

„Framework Theory Model“
Vosniadou, Vamvakoussi, & Skopeliti (2008)

vs.

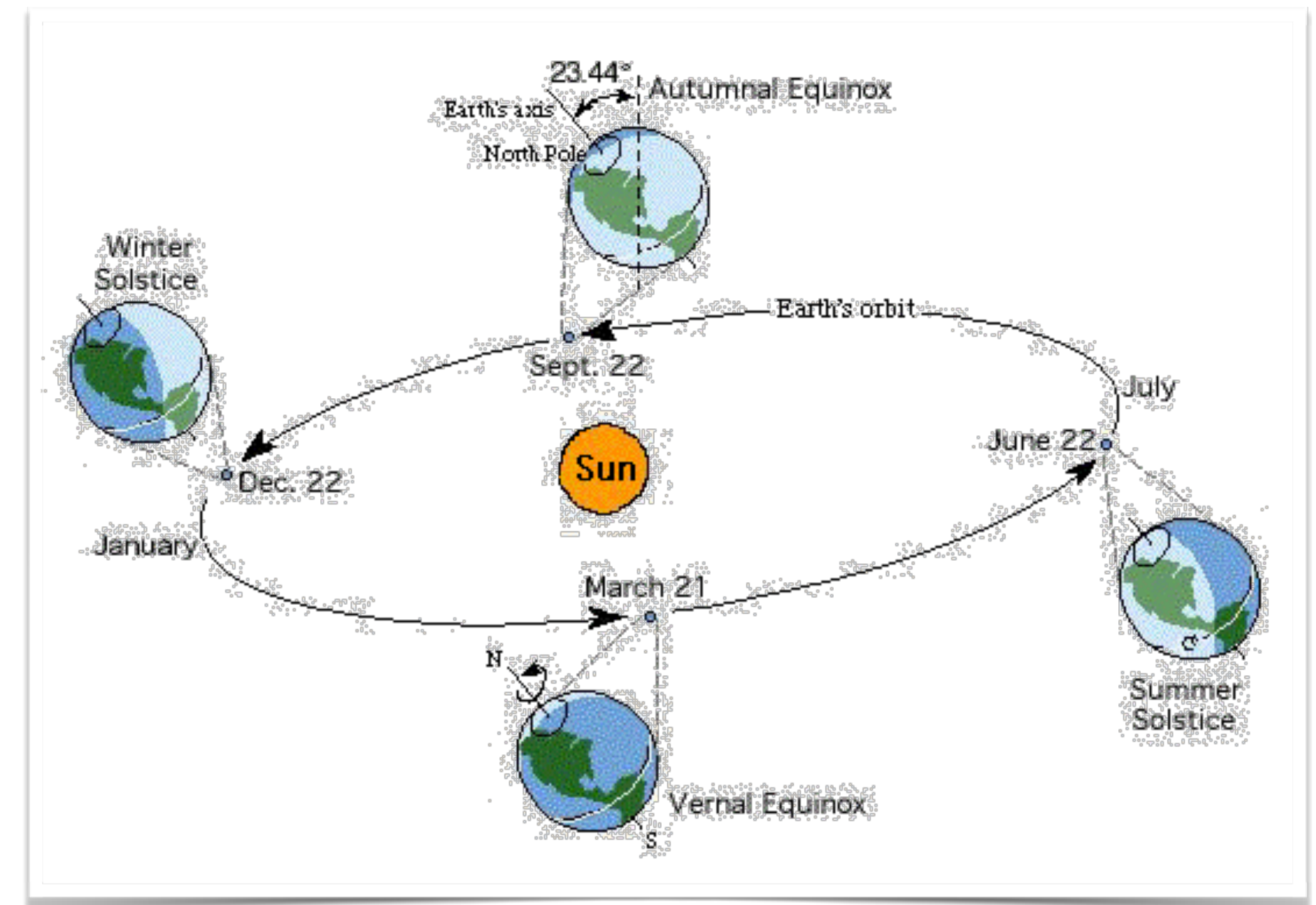
„Knowledge in Pieces“
di Sessa (2008)

1. Theoretical framework

concept development

Inclination vs. distance
Sadler, Schneps, & Woll (1989)

Misconceptions of climate seasons
David Hammer (1996)





1. Theoretical framework

student's conceptions

Early beginnings through chemical education research

Particle model for chemical reactions and phase transformation

Distinction between particles and particle systems

1. Theoretical framework

student's conceptions

Particle model to explain phenomena of gases

Hardly general use to explain phenomena

Rarely aids to explain everyday phenomena

However, when offered as a possible explanation, broad acceptance

1. Theoretical framework

student's conceptions

Significant

age-dependent with respect to the acceptance of the particle model

but

age-independent misconceptions of the atomic structure of matter



1. Theoretical framework

student's conceptions

3

Everyday experiences favor continuum perception

Mixing of continuum and discontinuum conceptions

Supported by erroneous illustrations in textbooks



1. Theoretical framework

student's conceptions

4 Even with acceptance two big misconception prevail!

No reproduction of the permanent motion of particles
Negation of the existence of empty space



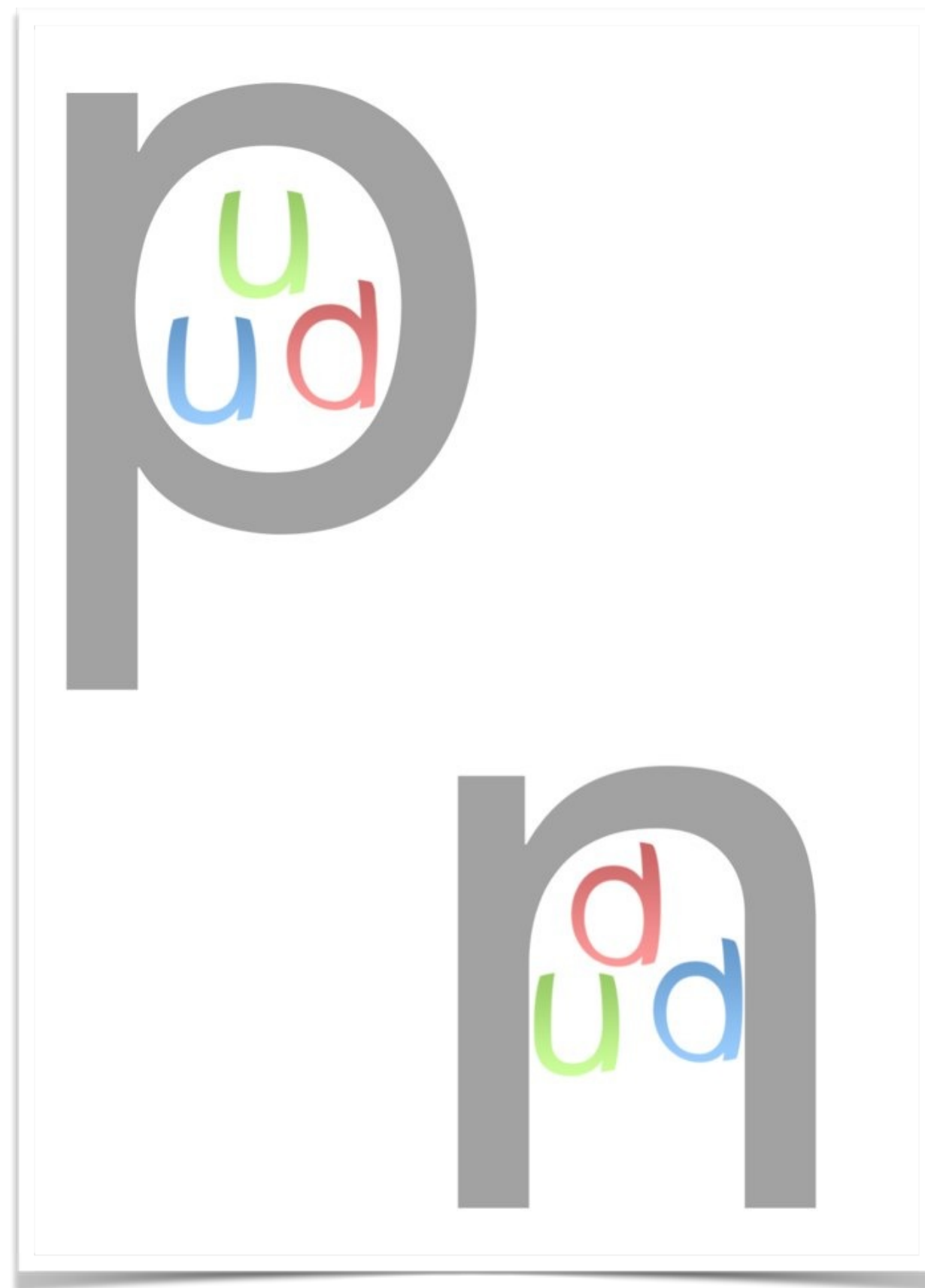
1. Theoretical framework

student's conceptions

5

Automatic transfer of macroscopic aspects and daily-life experiences
into the world of particles

2. Model conception



Avoiding known misconceptions

Permanent model character

Linguistic accuracy

Pure typography



3. Status quo

Probing acceptance
Wiesner & Wodzinski, 1996

- 1. Offer
- 2. Valuation

- 3. Paraphrasing
- 4. Transfer



Age group:
11-12 years

K = 0.725



3. Status quo

#	Key Ideas (KI)	Phase	S01	S02	S03	S04	S05	S06	S07	S08
1	Matter is anything that you can touch practically or theoretically	Paraphrasing of the KI	Green	Green	Green	Yellow	Green	Green	Green	Green
		Transfer of the KI (salt)	Green	Green	Green	Green	Green	Green	Green	Green
		Transfer of the KI (water)	Green	Green	Green	Green	Green	Green	Green	Green

3. Status quo

#	Key Ideas (KI)	Phase	S01	S02	S03	S04	S05	S06	S07	S08
1	Matter is anything that you can touch practically or theoretically	Paraphrasing of the KI	Green	Green	Green	Yellow	Green	Green	Green	Green
		Transfer of the KI (salt)	Green	Green	Green	Green	Green	Green	Green	Green
		Transfer of the KI (water)	Green	Green	Green	Green	Green	Green	Green	Green

#	Key Ideas (KI)	Phase	S01	S02	S03	S04	S05	S06	S07	S08
2	We describe the reality through models	Paraphrasing of the KI	White	Yellow	Green	Green	Red	Green	Green	Green
		Transfer of the KI (salt)	Green	White	Yellow	Green	White	Green	Yellow	White
		Transfer of the KI (water)	Green	Yellow	White	White	White	Green	Green	Green

3. Status quo

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		Transfer of the KI (water)								

#	Key Ideas (KI)	Phase	S01	S02	S03	S04	S05	S06	S07	S08
4	Atoms can be divided into two areas: the nucleus-area and the orbital-area	Paraphrasing of the KI								
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		Transfer of the KI (water)								

3. Status quo

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#	Key Ideas (KI)	Phase	S01	S02	S03	S04	S05	S06	S07	S08
10	The rest is empty space	Paraphrasing of the KI								
		Transfer of the KI (salt)								
		Transfer of the KI (water)								

3. Status quo

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#	Key Ideas (KI)	Phase	S01	S02	S03	S04	S05	S06	S07	S08
11	There are (different) atoms, which may combine to form molecules	Paraphrasing of the KI								
		Transfer of the KI (salt)								
		Transfer of the KI (water)								

3. Status quo

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#	Key Ideas (KI)	Phase	S01	S02	S03	S04	S05	S06	S07	S08
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		Transfer of the KI (water)								





3. Status quo

Particulate model of matter
& fundamental interactions



Optics

Mechanics

Electrodynamics

Cosmology

Radioactivity

Thermodynamics

Modern physics

Magnetism



Merci!
Let's talk!

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