

SHUFFLING THE PARTICLE DECK

TEACHER NOTES

DESCRIPTION

The Particle Cards activity is based on the particle cards produced by [Netzwerk Teilchenwelt](#), the main particle physics education and outreach program in Germany. Each card depicts one of the fundamental particles and its characteristics: mass, date of discovery, electric charge, etc. Students use these cards to become familiar with the Standard Model as an organized system of a limited number of fundamental particles with distinct characteristics and as constituents of more complex particles. In this activity, students, working in groups, organize the cards based on the characteristics of the particles. They decide how to do this and discover additional correlations based on their results. This activity is a foundation for learning about the Standard Model and for more complex particle physics activities. This activity parallels the methods used by scientists to organize the elements into the period table.

STANDARDS ADDRESSED

Next Generation Science Standards

Science and Engineering Practices

1. Asking questions
2. Developing and using models
4. Using mathematics and computational thinking
5. Constructing explanations
6. Engaging in argument from evidence
7. Obtaining, evaluating, and communicating information

Disciplinary Core Ideas – Physical Science

- PS1.A: Structure and Properties of Matter
- PS2.B: Types of Interactions
- PS2.C: Stability and Instability in Physical Systems
- PS3.B: Conservation of Energy and Energy Transfer
- PS3.C: Relationship between Energy and Forces

Crosscutting Concepts

1. Patterns
3. Scale, proportion, and quantity
4. Systems and System Models

Common Core Literacy Standards

Reading

- 9-12.4 Determine the meaning of symbols, key terms . . .
- 9-12.7 Translate quantitative or technical information . . .

IB Physics Standard 7: The Structure of Matter

- Standard 7.3 Understandings: Quarks, leptons, and their antiparticles and exchange particles

ENDURING UNDERSTANDING

The fundamental particles are organized according to their characteristics in the Standard Model.

LEARNING OBJECTIVES

As a result of this investigation, students will be able to:

1. Explain the reasoning used to organize the cards.
2. Give an account of how fundamental particles relate to each other based on their characteristics.
3. Describe how particles compare with their antiparticles.

PRIOR KNOWLEDGE

None needed. The main part this activity is actually best done *before* students have been exposed to the Standard Model.

MATERIALS

Netzwerk Teilchenwelt Particle Cards, one set for each 3-8 students
Small tables

BACKGROUND MATERIAL

Searching for the Building Blocks of Matter,
<http://ed.fnal.gov/projects/exhibits/searching/>

RESOURCES

- Particle cards, https://quarknet.org/sites/default/files/particlecardseng_0.pdf (must be cut out)
- Symmetry Interactive Standard Model, <http://www.symmetrymagazine.org/standard-model/>

IMPLEMENTATION

This activity works best if it is implemented prior to the student's introduction to the Standard Model. Begin by giving each student group a deck of particle cards. You should instruct the groups that they have about 15 minutes to organize the cards based on the properties printed on the front of each card: matter vs. antimatter, mass, three kinds of charge, and lifetime. You should assure students that whatever organization they make will be fine and likely show insights. You should circulate as groups work, encouraging their progress. If students have trouble with what to do, you can make suggestions, e.g. "Why don't you try lining them up by mass to start...and then go from there?"

About 2/3 of the way into the allotted work time, you should ask each group to choose a spokesperson to briefly explain their organizational scheme. At the end of the work time, each group should report to the others.

As the students present, you can reinforce their insights by commenting on instances when their organizational scheme aligns with the Standard Model organization. You may want to comment on the similarities between the students efforts with the methods used to organize elements into the period table to make connections with their chemistry studies.

ASSESSMENT

The most appropriate assessment for this activity is formative. Criteria might include:

- Clear explanation of organizational scheme
- Describing more than one method of organizing
- Noticing the correct connection between particles and anti-particles