TUTTI QUANTUM

EN

Welcome to the world of fundamental particles! Here, the rules of Quantum Mechanics and Einstein's Relativity make particles appear from nowhere, travel through walls and behave in extraordinary ways! Will you ever be able to understand how it functions? With Tutti Quantum, you'll learn seven simple rules for connecting particles so you can build the most extravagant Feynman diagram. Each graph corresponds to a real-world particle phenomenon, whether that is an explanation of the blue sky or the discovery of the Higgs boson. The rarest processes are worth a Nobel prize... and if you find them, you'll win – the game, that is!

More information about un-solved, rules in other languages and a useful document are available at: **un-solved.com/game**

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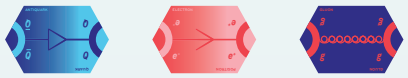
HELVETIQ

unsolved

GAME COMPONENTS

- 44 elementary particle cards:



13 quarks 8 electrons 12 gluons

7 photons 4 Higgs bosons

4 reference cards

1 first-player pawn

42 score tokens

GOAL OF THE GAME

The game can be played either competitively or cooperatively, but we suggest starting with the competitive mode as you familiarize yourself with the rules. In both modes, **your goal is to place elementary particles together to form a Feynman diagram, and so earn yourself the most points**, and the winner will have found the rarest process in nature.

COMPETITIVE MODE

The players compete to score the most points. The more points you score, the rarest the process diagram is.

SETUP

- Give each player a reference card.
- Shuffle all the particle cards together. If there are 3 players, randomly discard 5 cards and put them back in the box: These won't be used.
- Give each player one card: This card is kept secret, and will be added to your diagram after the final round. Remember it well!
- Place the remaining particle cards face down in a draw pile. Leave enough space for each player to make a diagram in front of them.
- Sort the score tokens by type and flip half of them so that all 7 different sides are visible. Scoring is not limited to the upturned sides: You can use the reverse side of the tokens.
- Draw the appropriate number of cards and place them face up in the center of the table. The chart below specifies the number of cards revealed and the number of rounds played:

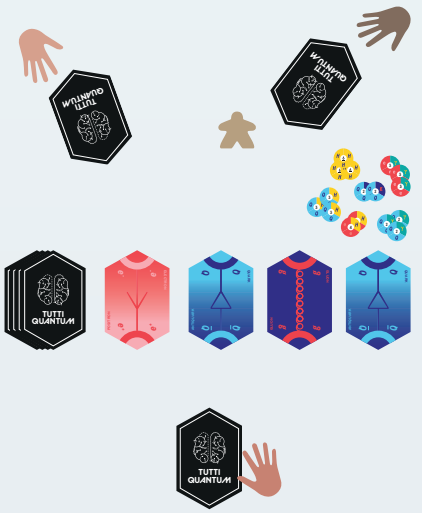
PLAYERS	CARDS	ROUNDS
2	3	14
3	4	9
4	5	8

The youngest player will play first, so takes the first-player pawn.

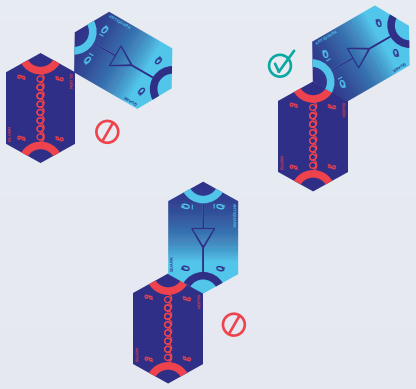
HOW TO PLAY

Each player will make their own diagram. The first player chooses an upturned particle card from the center, and immediately places it in their diagram. Play continues clockwise, with each player taking a card in the same way, and the first player will take the final card. The first-player pawn then passes to the next player clockwise, new cards are drawn and placed face up on the table, and the next round begins.

The game ends when there are no more cards to draw. All players reveal their secret card and place it in their diagram.



Rules for playing cards
The players place their first card somewhere in front of them. All subsequent cards must be placed adjacent to at least one card already on the table. The cards must be placed in such a way that the lines meet at the points, which are called vertices (vertices is the plural of vertex).



A complete vertex is a group of 3 cards arranged around the same point. Some vertices are valid – since they represent how particles interact with each other – and so will give you points; however, invalid vertices will instead lose you points. When you complete a vertex by playing a third card around it, you immediately place the scoring token on it, to show the points earned. See the "Scoring" section below.

The game ends once all the cards have been drawn and placed, and the players should all have the same number of particles in front of them. Everyone counts their points, and the winner is the one with the most points. In the event of a tie, the player with the fewest invalid vertices wins. If the players are still tied, the winner is the one with the most vertices worth 6 points, then 4 points, 3 points and then finally, 2 points.

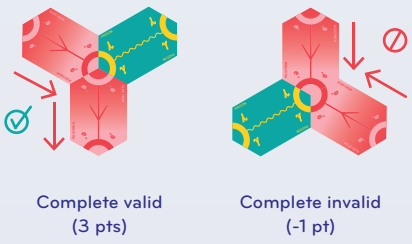
SCORING

You score points for every valid complete vertex in your diagram. The vertices worth more points represent rarer natural processes.

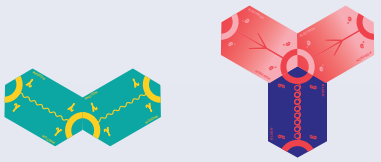
The illustration on the right shows every possible complete vertex.

All other complete vertices are invalid, and so are vertices composed of only 2 different types of particle. At the end of the game you will lose 1 point per invalid vertex, since these do not appear in nature. Incomplete vertices that are composed of 2 of the same particle are considered to be valid, but do not give you any points. Vertices with only 1 particle are ignored and they don't lose you points.

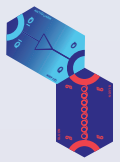
Important: The electrons and quarks are electrically charged particles, indicated by the arrow on those cards. They must be placed in such a way that the arrow continues in the same direction from one card to the next, otherwise they will create an invalid vertex.



Complete valid (3 pts) Complete invalid (-1 pt)

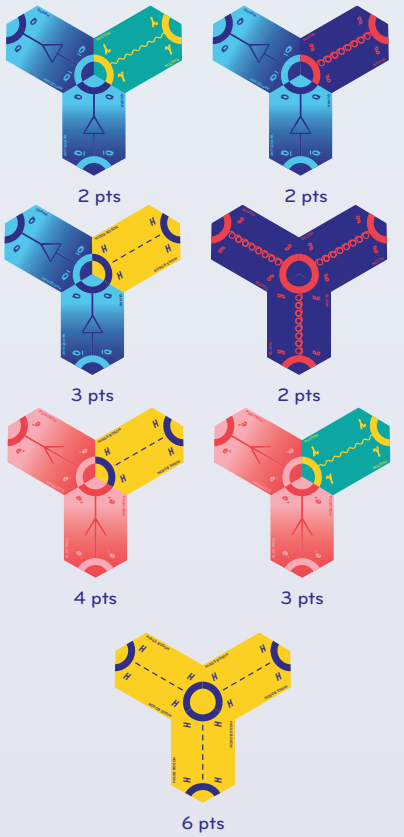


Incomplete valid (0 pt) Complete invalid (-1 pt)



Incomplete invalid (-1 pt)

COMPLETE VALID VERTICES



ADVANCED SCORING

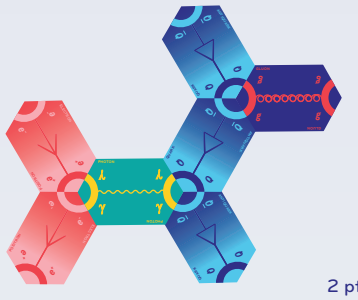
You can score 2 bonus points for every valid loop in your diagram at the end of the game. A loop is a closed hexagon composed of 6 cards. For a loop to be valid, it must be composed of 6 valid (complete or not) vertices. You do not get bonus points for invalid loops.

VALID LOOP

EXPERT SCORING

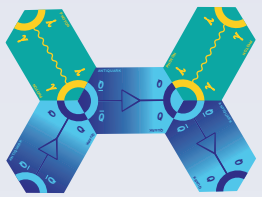
Are you now an expert in particle physics and ready to go to the next level? Over the course of the game, try to form the following sub-diagrams. Count your points in the usual way at the end of the game, then add points for the sub-diagrams.

1. **Why atoms stay together:** In the world of particles, the electric force is carried by photons. It keeps electrons and quarks together in atoms.



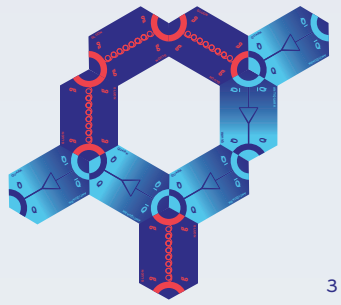
2 pts

2. **The blue sky:** Light is made up of photons, and this diagram illustrates how it is reflected by matter – i.e. quarks and electrons. This process is more likely to appear with blue light, hence the sky's color.



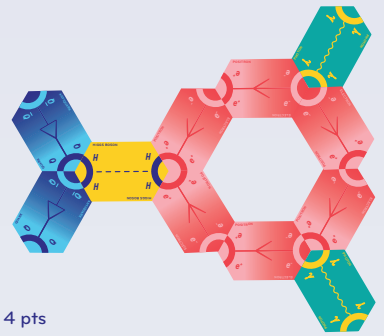
2 pts

3. **Nobel Prize 2004:** Diagrams like this one have shown that the force inside nuclei is stronger when the distance is longer and gets weaker and weaker as the distance gets shorter, in a similar way to a spring being pulled out.



3 pts

4. **The discovery of the Higgs boson:** In 2012, a new particle was discovered at CERN through its decay into two photons, which are light particles.



4 pts

Important: Due to the number of cards needed to build these diagrams, this variant only works with 2 players (when playing competitively). If you have more than 2 players, you could divide the players into 2 teams, or instead play cooperatively.

COOPERATIVE MODE

In this mode, the players all work together on the same diagram, and the goal is to make a valid diagram worth as many points as possible.

SETUP

- Shuffle all the particle cards together and place them on the table in a facedown draw pile.
- Draw the top card from the pile and place it on the table: This starts the common diagram.
- Each player draws 2 cards and puts them in their hand.
- Discard the next card from the draw pile without revealing it.

HOW TO PLAY

The players must never talk about the cards in their hand. They may tell the others where they would like to play a card or where the others should not play, but they are not allowed to be more precise.

After separately looking at their cards, the players decide together who will begin. They take turns clockwise, with each player placing one card from their hand into the common diagram. The placement and scoring rules are the same as for the competitive mode. Once a player has placed a card, they decide which of the following two options to play:

— Draw 1 card so your hand goes back up to 2 cards AND discard the top card from the draw pile without revealing it.

— Discard the card left in your hand without revealing it AND then draw 2 new cards.

If the draw pile is empty, skip this step and play until everyone has played all the cards in their hands.

END OF THE GAME

When all the players are out of cards, the game ends. If the diagram contains invalid vertices, the players lose the game. Reminder: Incomplete vertices featuring the same particle twice are valid, but all other incomplete vertices are invalid.

If your diagram is entirely valid, you have won the game! Count how many points your diagram is worth and check how well you did in the table below:

SCORE	RESULT
> 38 points	You will probably win the next Nobel Prize!
35-38 points	You should consider doing a PhD in Particle Physics!
32-34 points	You must have worked as a team of real experimental physicists!
29-31 points	You are starting to understand the secrets of fundamental particles, but you'll need to communicate better in the future!
26-28 points	The secrets of fundamental particles lie before you, but you need to spend more time studying in order to understand them.
< 26 points	You need to be more careful when playing around with subatomic particles. Study more and try again!

Have you got the hang of the cooperative mode? Then try making loops and using the advanced scoring rules. Add even more challenge by embarking on one of the expert scoring "missions"!

CREDITS

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