Build your research team and use the tools of structural biology to make ground-breaking discoveries! Deposit your structures to the Protein Data Bank to further advances in biology and medicine! You have competition, so work fast and try not to get scooped!

PDB50 the game.

Created by RCSB PDB (rcsb.org)

This work is licensed under the Creative Commons Attribution-NonCommercial 4.0 International License.
To view a copy of this license, visit http://creativecommons.org/licenses/by-nc/4.0/
or send a letter to Creative Commons, PO Box 1866, Mountain View, CA 94042, USA.

Image: yeast RNA polymerase II elongation complex (PDB ID 1I6H)
Source: pdb1I6H.rcsb.org
Welcome to PDB50!

Every biological molecule has a shape. Scientists perform specialized experiments to visualize and record these molecular shapes at the atomic level, providing insight into the functions of these molecules, their roles in life processes, and how drugs and vaccines can be developed to target diseases. Since 1971, over 175,000 atomic structures of proteins and nucleic acids (DNA, RNA) have found their home at the Protein Data Bank (PDB), the single worldwide, open-access repository for three-dimensional structures of biological macromolecules. Every day, students, educators, and scientists use PDB content and tools free of charge to explore, understand, and advance the fields of biology and biomedicine.

This game celebrates the 50th anniversary of the PDB by giving players the opportunity to explore the process of structure discovery. Build your research team and use the tools of structural biology to make ground-breaking discoveries. Prepare samples and grow crystals. Use X-ray crystallography, electron microscopy, and NMR spectroscopy to collect the data necessary to complete a project and deposit a structure to the PDB. Then, move on to the next project…but keep an eye on the competition and try not to get scooped!

Explore the world of biology and biomedicine at the molecular level at wwpdb.org.

Game Contents

- 1 Game Board
- 32 Innovation cards (28 PDB Deposition cards + 4 Additional Action cards)
- 1 Leader token (💰)
- 4 Principal Investigator markers
- 40 Researcher tokens (10 x 🔍 / 10 x 📈 / 10 x 🤝 / 10 x 🌟)
- 20 Sample tokens (🔍)
- 20 Crystal tokens (💎)
- 60 Data tokens (20 x ■ / 20 x ● / 20 x ▲)
- 30 Achievement tokens (⭐)

Game Setup

1. Place the game board in the middle of the play area.
2. Shuffle all of the Innovation cards and place the deck face-down next to the board.
3. Draw three Innovation cards and place them on the three Innovate boxes along the bottom edge of the board. Each card should be placed face up and positioned such that the top edge of the card hides the red text box and completes an intact Action box.
4. Separate different token types (🔍💎 ■ ● ▲ ⭐️ 🍀 🌈 🛡️ ✒️) into piles next to the board. This area will be referred to as “Supply” hereafter.
5. Each player should select a Principal Investigator marker (red, green, blue, or yellow) and acquire one 🔍 Researcher token of the same color from Supply.
6. Select one player to start with the Leader token. This can be done randomly or according to a criterion agreed upon by all players (e.g., oldest player, player with the most publications, player who spent the longest time in graduate school, etc.)

7. Select one token of each Data type ( ). From this group, the player to the right of the Leader selects and acquires the token of their choice. Then, the player to their right chooses and acquires one of the two remaining tokens. Finally, the player to their right (the player to the left of the Leader) acquires the remaining token.

**Initial Game Setup**
Game Rules

1. A game comprises multiple rounds. During each round, each player will take one or more turns.
2. At the beginning of a round, the player holding the [leader] token takes the first turn.
3. After the Leader has taken the first turn, play proceeds to their left, with each player taking a turn (skipping players who are unable to take a turn) until no player can take additional turns. If any players have more than one [researcher] token, several circuits of the players may be required to complete a round.
4. On each turn, a player must place one (and only one) of their [researcher] tokens on an Action box (marked by [innovation]), either on the game board or on an Additional Action (Innovation) card they have acquired. Alternatively, the player may discard a [researcher] token using the Graduate / Retire Action.
5. A player may not select an Action they are unable to perform (i.e., a player cannot return to Supply a token they do not already possess).
6. When an Action box has been selected by placement of a [researcher] token, the player who placed the token must then immediately perform the associated Action. There are two exceptions to this rule: [researcher] tokens gained using the Recruit Researcher Action and Innovation cards claimed using an Innovate Action are not acquired until the current round has ended.
7. After a player has performed one Action, their turn is finished and play passes to the player on their left.
8. A player who has at least one un-played [researcher] token must take a turn.
9. A player who lacks any un-played [researcher] tokens cannot take a turn and is skipped.
10. A [researcher] token placed in an Action box remains there until the end of the round and cannot be used again until the next round.
11. During a round, a player cannot select an Action that has already been performed that round. The exception is the Graduate / Retire Action, which can be performed multiple times by any player during a round.
12. A player who needs to play a [researcher] token but finds no open, usable Action boxes must perform the Graduate / Retire Action.
13. A player cannot perform the Graduate / Retire Action if doing so would leave them with a total of zero [researcher] tokens.
14. Tokens can be acquired from or returned to Supply only as part of an Action or as part of Game Setup.
15. When no player can take a turn, a round ends. All players collect their [researcher] tokens and acquire any Innovation cards that have been claimed during the round, and new Innovation cards are drawn and placed on open Innovate Action boxes. A new round then begins, starting with the player who has the [leader] token.
16. Endgame. A game ends at the conclusion of a round during which any player reaches 12 or more [achievement] Achievement. The winner is the player with the most [achievement] Achievement at the end of the game. The winner may not necessarily be the player who triggered the endgame. Ties are won by the player with the most total Data (⬛+●+▲) tokens.
Action Descriptions

- **Recruit Researcher.** Obtain a Researcher token of your color from Supply and place it on the Recruit Researcher Action box. You will collect both this token and the placed token at the end of the round. **NOTE:** the Recruit Researcher Action cannot be performed during the first round of a game.

- **Lead the Field.** Acquire the Leader token from the player who has it. You will take the first turn next round and will retain the Leader token until another player selects this Action.

- **Publish Initial Results.** Acquire an Achievement token from Supply.

- **Prepare Samples.** Acquire either one or two Sample tokens from Supply, depending on which of the two Prep Samples Actions has been selected.

- **Grow Crystals.** Return one Sample token to Supply and acquire one Crystal token from Supply in exchange.

- **Collect Data: X-ray Crystallography.** Return one Crystal token to Supply and acquire either two Data tokens OR one Data token from Supply in exchange.

- **Collect Data: NMR Spectroscopy.** Return two Sample tokens to Supply and acquire either one Data token OR one Data token from Supply in exchange.

- **Collect Data: Electron Microscopy.** Return one Sample token to Supply and acquire either two Data tokens OR one Data token from Supply in exchange.

- **Analyze Data.** Return either two Data tokens OR two Data tokens to Supply and acquire one Data token from Supply in exchange.

- **Graduate / Retire.** Return a Researcher token to Supply and acquire one Data token (either , , OR ) from Supply in exchange. The returned Researcher will not be collected by the player at the end of the round.

- **Innovate.** There are three Innovate Actions, each with an Innovation card on it. Upon selecting an Innovate Action, return to Supply all the Data tokens shown in the Action box. The claimed Innovation card and the placed Researcher token will remain on the board until the end of the round, at which point they are acquired and a replacement card drawn.
  - PDB Deposition cards are worth (three) Achievement.
  - Additional Action cards provide an additional Action option to the player who has acquired them:
    - **Automation.** Acquire either a Sample token OR a Crystal token from Supply.
    - **Electron Crystallography.** Return one Crystal token to Supply and acquire one Data token from Supply in exchange.
    - **IH/M.** Return two Data tokens to Supply and acquire one Data token from Supply in exchange.
    - **XFEL.** Return one Crystal token to Supply and acquire one Data token from Supply in exchange.
The HIV-1 capsid protects the HIV genome and delivers it to infected cells (PDB ID 3j3q).

Electron Crystallography uses an electron microscope to collect structure data from tiny crystals.

An X-ray Free Electron Laser produces rapid X-ray pulses that can be used to collect structure data from large numbers of microscopic crystals.

Integrative/Hybrid Methods combine computation with multiple experimental techniques to answer complex structural questions.

Electron Crystallography

Automation helps maximize the effectiveness of sample preparation.

Laboratory automation helps maximize the effectiveness of sample preparation.

(CARD BACK)
Insulin is a hormone essential for controlling blood sugar (PDB ID 4ins).

Hemoglobin transports oxygen from the lungs to the rest of the body (PDB ID 4hhb).

Transfer RNA translates the language of the genome into the language of proteins (PDB ID 4tna).

Green fluorescent protein from glowing jellyfish has revolutionized biological research (PDB ID 1gfl).

Collagen provides structure and strength for skin, tendons, and bones (PDB ID 1bkv).

The immune system uses antibodies to target invading viruses and bacteria (PDB ID 1igt).

Our bodies use ferritin to store and manage essential iron (PDB ID 1fha).

Nucleosomes store and protect our genome in chromosomes (PDB ID 1aad).

Beta-lactamase destroys drug molecules in antibiotic-resistant bacteria (PDB ID 4eyl).
Plants use RuBisCo to remove carbon from the atmosphere and incorporate it into sugars (PDB ID 1rcx).

Voltage-gated sodium channels transmit signals in the nervous system (PDB ID 6j8j).

Plants use nitrogenase to convert atmospheric nitrogen into biologically useful forms (PDB ID 1n2c).

Capsaicin receptor TRPV1 helps detect the heat of both high temperatures and spicy foods (PDB ID 5is0).

Drug target HIV-1 reverse transcriptase makes DNA copies of the viral RNA genome (PDB ID 1hnv).

SARS-CoV-2 spike protein is the target of COVID-19 vaccines (PDB ID 6vxx).
The **G-protein coupled receptors** are a diverse family of sensing and signaling proteins targeted by many drugs (PDB ID 3sn6).

**ATP synthase** uses molecular motors to store chemical energy (PDB ID 5fij).

Cells use the **major histocompatibility complex** to tell the immune system when they are infected (PDB ID 1hsa).

**CRISPR-Cas** is a bacterial defense against viruses that has been adapted into a cutting-edge scientific tool (PDB ID 4u7u).

Cells use **proteosomes** to break down old or damaged proteins for recycling (PDB ID 5gjr).

**Photosystem II** converts solar energy into chemical energy (PDB ID 4pbu).

A bacterium may use **pilus machines** to control its movement (PDB ID 3jc8).

**Ribosomes** are the complex molecular machines that build proteins (PDB ID 4v5d).

Multiple copies of two proteins assemble into the highly symmetrical shell of **Zika virus** (PDB ID 5ire).