

PROTEIN DATA BANK



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)

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Image: yeast RNA polymerase II elongation complex (PDB ID 1i6h)
Source: pdb101.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 www.pdb.org.

Game Contents

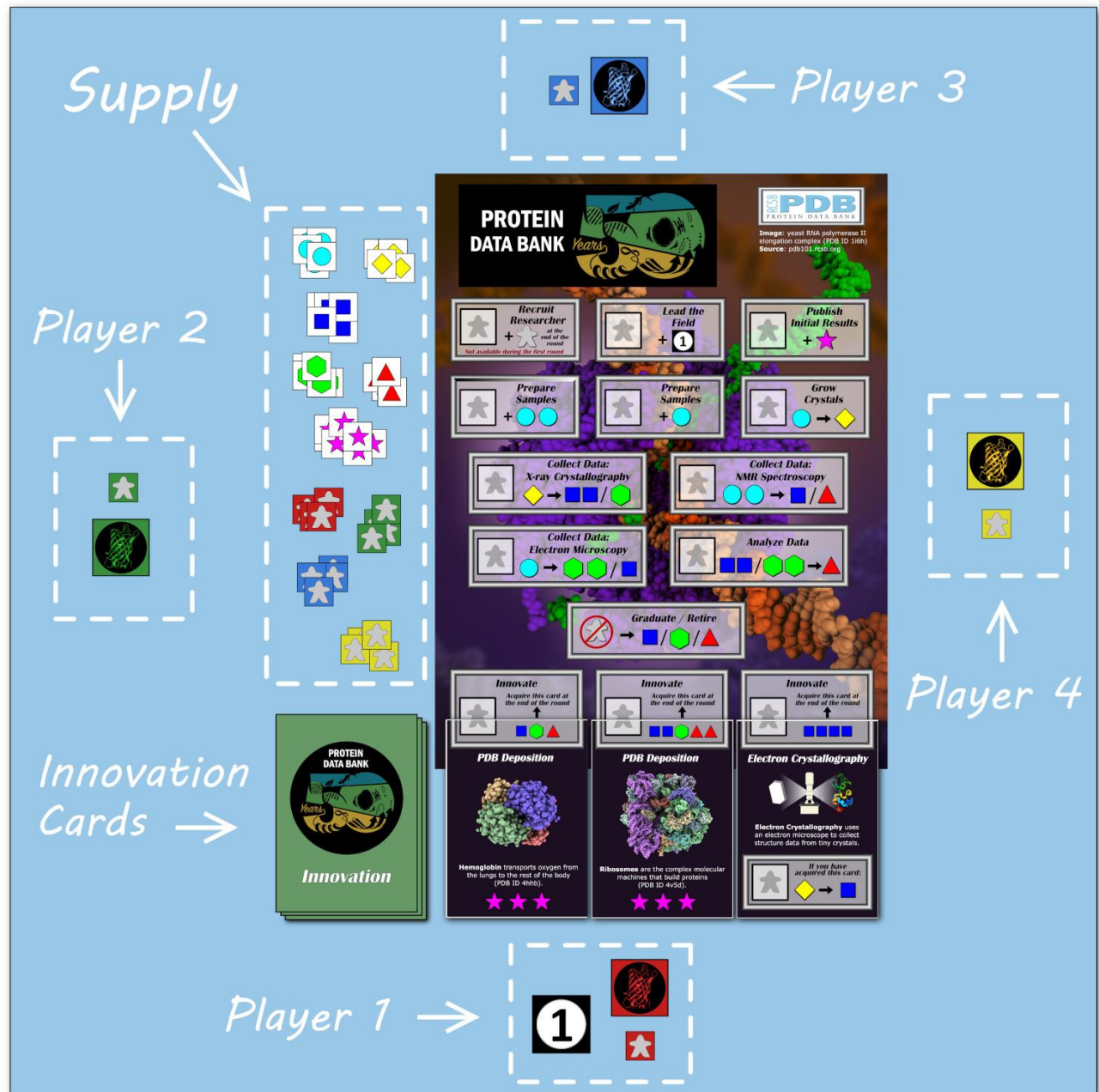
- 1 Game Board
- 32 Innovation cards (28 PDB Deposition cards + 4 Additional Action cards)
- 1 Leader token (👤)
- 4 Principal Investigator markers
- 40 Researcher tokens (10 x 🔴 / 10 x 🟢 / 10 x 🔵 / 10 x 🟡)
- 20 Sample tokens (💧)
- 20 Crystal tokens (💎)
- 60 Data tokens (20 x 🟠 / 20 x 🟡 / 20 x 🔴)
- 30 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 **1** 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 ) , 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. The winner is the player with the most  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.

PROTEIN DATA BANK



Image: yeast RNA polymerase II elongation complex (PDB ID 1i6h)
Source: pdb101.rcsb.org

Recruit Researcher
at the end of the round

Not available during the first round

Lead the Field

Publish Initial Results

Prepare Samples

Prepare Samples

Grow Crystals

Collect Data: X-ray Crystallography

Collect Data: NMR Spectroscopy

Collect Data: Electron Microscopy

Analyze Data

Graduate / Retire

Innovate
Acquire this card at the end of the round

Cover this red box with a new card.

Innovate
Acquire this card at the end of the round

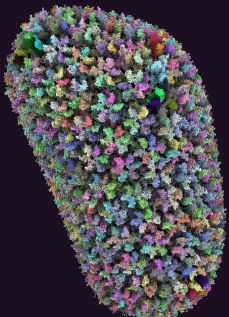
Cover this red box with a new card.

Innovate
Acquire this card at the end of the round

Cover this red box with a new card.

Cards

PDB Deposition



The **HIV-1 capsid** protects the HIV genome and delivers it to infected cells (PDB ID 3j3q).

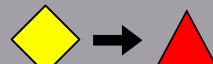
★ ★ ★

XFEL

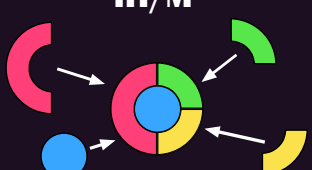


An **X-ray Free Electron Laser** produces rapid X-ray pulses that can be used to collect structure data from large numbers of microscopic crystals.

If you have acquired this card:



IH/M

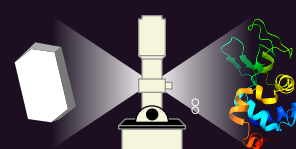


Integrative/Hybrid Methods combine computation with multiple experimental techniques to answer complex structural questions.

If you have acquired this card:



Electron Crystallography

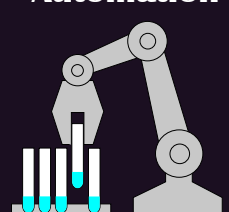


Electron Crystallography uses an electron microscope to collect structure data from tiny crystals.

If you have acquired this card:



Automation



Laboratory **automation** helps maximize the effectiveness of sample preparation.

If you have acquired this card:



PROTEIN DATA BANK



Innovation

(CARD BACK)

PDB Deposition

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

PDB Deposition

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

PDB Deposition

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

PDB Deposition

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

PDB Deposition

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

PDB Deposition

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

PDB Deposition

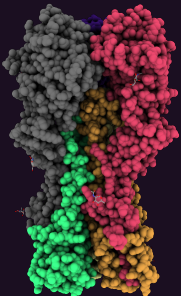
Our bodies use **ferritin** to store and manage essential iron (PDB ID 1fha).

PDB Deposition

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

PDB Deposition

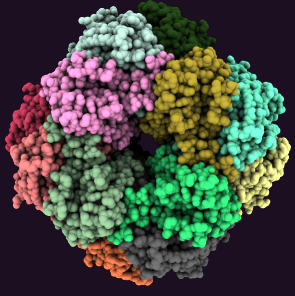
Beta-lactamase destroys drug molecules in antibiotic-resistant bacteria (PDB ID 4eyl).



PDB Deposition

Hemagglutinin is the weapon that the influenza virus uses to attack our cells (PDB ID 1ruz).

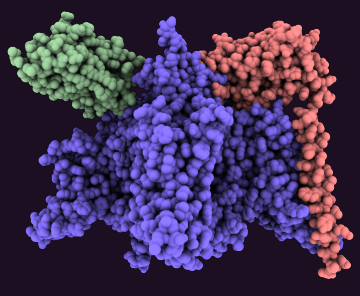




PDB Deposition

Plants use **RuBisCo** to remove carbon from the atmosphere and incorporate it into sugars (PDB ID 1rcx).

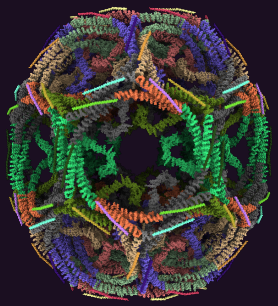




PDB Deposition

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

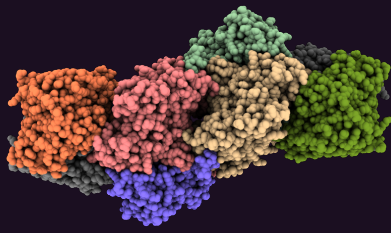




PDB Deposition

Clathrin is an elegant cage for transporting fragile cargos within cells (PDB ID 1xi4).

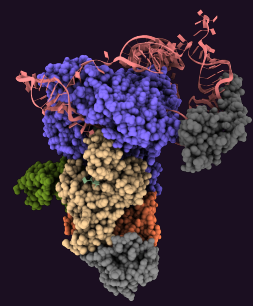




PDB Deposition

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

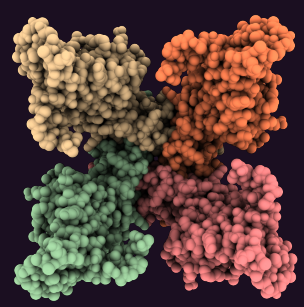




PDB Deposition

Telomerase protects our chromosomes as we age (PDB ID 6d6v).

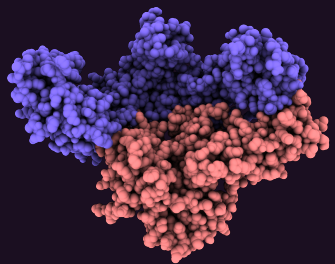




PDB Deposition

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

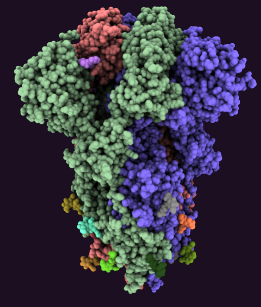




PDB Deposition

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

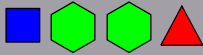




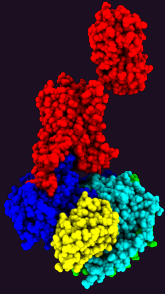
PDB Deposition

SARS-CoV-2 spike protein is the target of COVID-19 vaccines (PDB ID 6vxx).

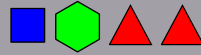




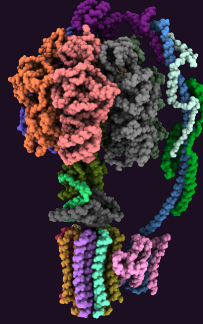
PDB Deposition



The **G-protein coupled receptors** are a diverse family of sensing and signaling proteins targeted by many drugs (PDB ID 3sn6).



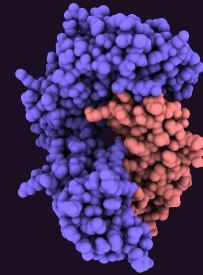
PDB Deposition



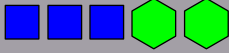
ATP synthase uses molecular motors to store chemical energy (PDB ID 5fij).



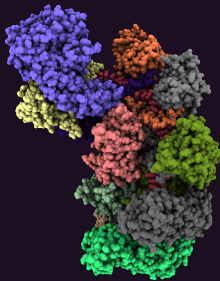
PDB Deposition



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



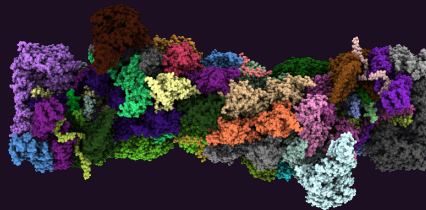
PDB Deposition



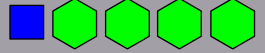
CRISPR-Cas is a bacterial defense against viruses that has been adapted into a cutting-edge scientific tool (PDB ID 4u7u).



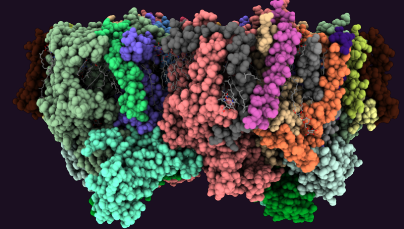
PDB Deposition



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



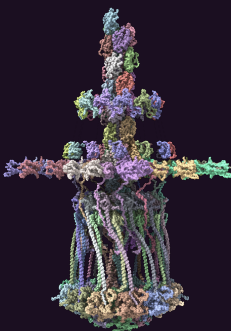
PDB Deposition



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



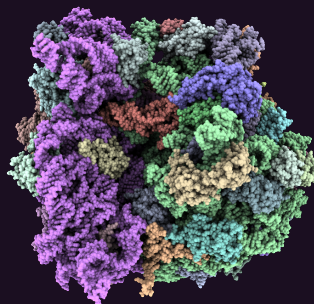
PDB Deposition



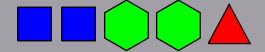
A bacterium may use **pilus machines** to control its movement (PDB ID 3jc8).



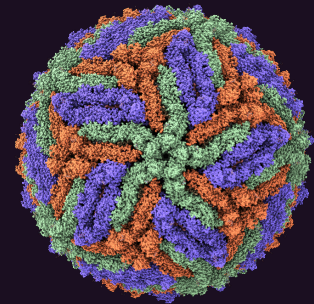
PDB Deposition



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



PDB Deposition



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



Tokens

