BOUND!

Bound! is a card game where players compete to match the most DRUGS to PROTEIN TARGETS

Target Audience:

Ages 12 and up, with additional options for all ages

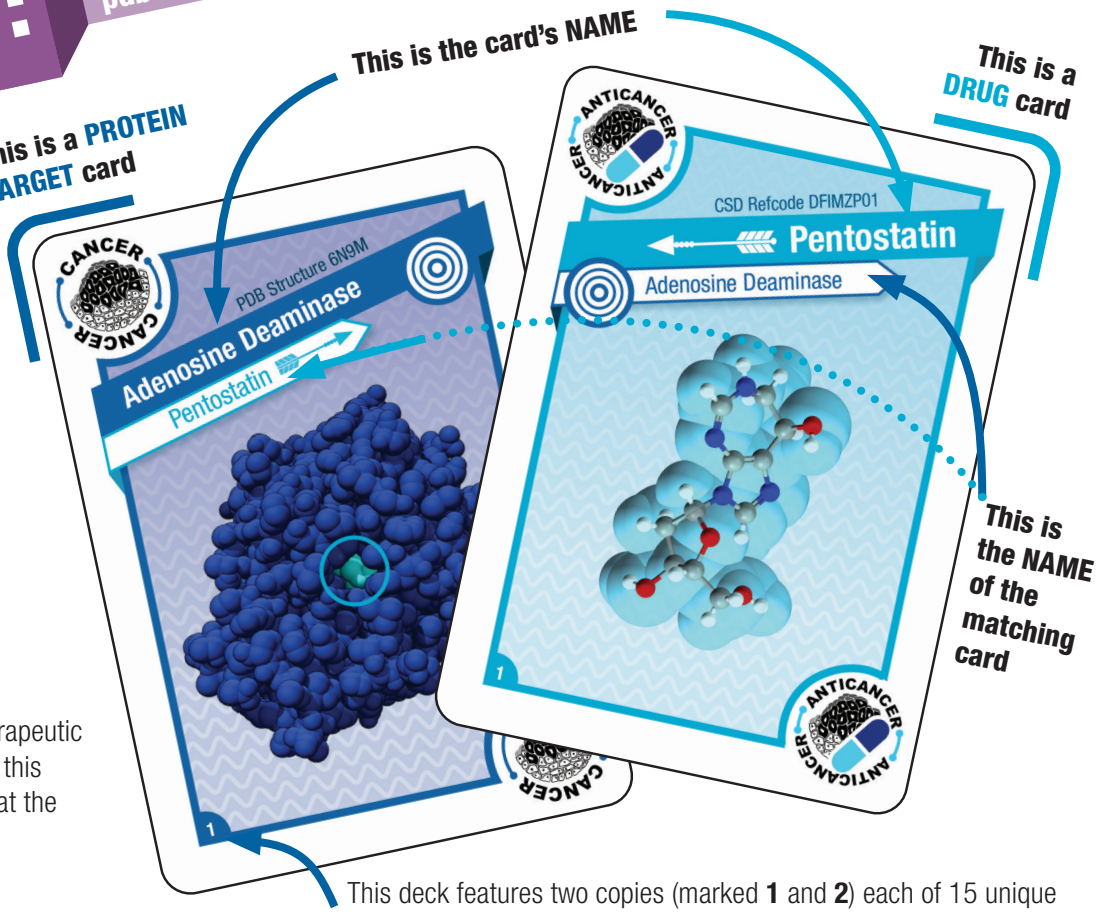
Contents

RCSB PDB PROTEIN DATA BANK — **rcsb.org**

RCSB PDB-101 — **pdb101.rcsb.org**

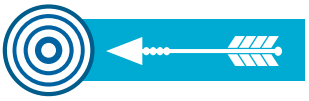
CCDC advancing structural science — **ccdc.cam.ac.uk**

Get to know the cards



This deck features two copies (marked **1** and **2**) each of 15 unique pairs of drugs and the protein targets with which they interact (60 cards total). Use the numbers to separate the cards into 2 decks for memory games (page 4).

Target-Drug Pairs



Target and *arrow* icons

A protein that interacts with a therapeutic drug is referred to as a **target**. In this deck, protein targets are marked at the top right with a *target* icon.

Each protein target card has an image of the atomic model of the protein with the drug bound created using data from the Protein Data Bank (PDB).

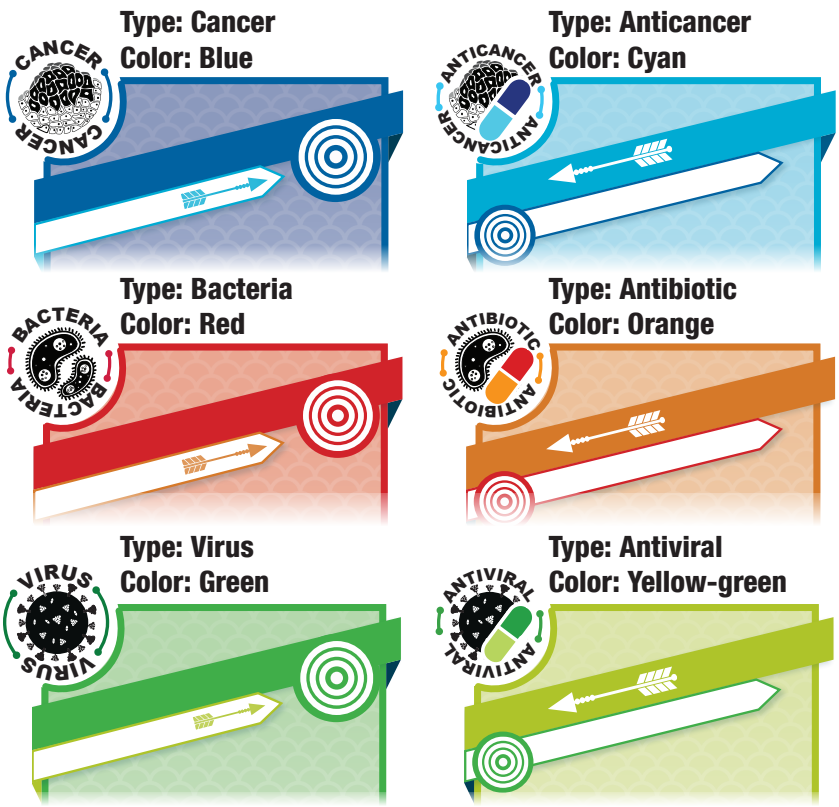
Similarly, each **drug** is marked at the top with an *arrow* icon and the card shows an image of the drug molecule created using data from the Cambridge Structural Database (CSD).

The molecule name within the colored banner at the top of the card is referred to in the instructions as the card's **NAME**. The name of the molecule that interacts with the molecule pictured on the card is listed underneath within the white banner, and identifies the second card that completes this card's matched drug-target pair.

Types and Colors

Each card has a **TYPE**. Each Type is identified by both a distinct *color* and a *unique icon* in the upper left corner of the card.

There are six different card Types that encompass three varieties of target-drug pairing: Cancer to Anticancer, Bacteria to Antibiotic, and Virus to Antiviral.



BOUND! Instructions

Bound! is a game for 2-5 players ages 12 and up, and uses the full 60-card deck.

Getting started

1. Shuffle the deck and deal each player **seven** cards. Players may look at their own cards, but should keep them secret from other players except when instructed by the rules.
2. Place the undealt cards face-down in a pile in the center of the play area. This is the **draw pile**. Any cards that are discarded should be placed face up in a pile next to the draw pile. This is the **discard pile**.
3. Choose a player to take the first turn. After a player has taken their turn, the player to their left may take the next turn.

On a player's turn

4. The player must request a card from another player. They may do it in only one of two ways:
   - Request a card of a particular **TYPE** from a specific player (e.g. *John, do you have a Cancer card?*), or
   - Request a specific card by **NAME** from all players (e.g. *I need the Estrogen Receptor Beta card.*)
5. If the player or players receiving a request have the requested card in their hand, they must give it to the requesting player.
6. If a player receiving the request has *more than one card* of the requested Type or Name, they may choose which of those cards to give to the requesting player.
7. If two players have cards with the requested Name, the requesting player decides which of those two players will give them their card.
8. A player receiving a requested card must then immediately reveal a pair that matches in one of two ways:
   a. *A Drug and its specific Target.* This pair remains on the table in front of the player and will be worth one (1) point at the end of the game. Example (shown): Ribosome + Erythromycin.

   b. *Two cards of the same Type (and Color).* These cards should be placed in the discard pile and do not score points. Example (shown): Erythromycin (Antibiotic) + Novobiocin (Antibiotic).

9. The card that was requested does not have to be part of the matched pair that the player reveals.
10. If the player does not receive the requested card, they must draw a card from the draw pile. They may then either lay down a matched Drug-Target pair, discard a pair of cards of the same Type, or pass.

Progressing and ending the game

11. The turn then ends and the player to the left takes their turn.
12. If the draw pile is emptied, the discard pile is shuffled and becomes the new draw pile.
13. The game ends when one player has no cards remaining in their hand.

Counting the results

14. When the game has ended, players score:
    - One **(1) point** for each matched Drug-Target pair they revealed during the game (see 8a).
    - Cards remaining in players' hands do not score.
    - Cards discarded as matched *Type* pairs do not score (see 8b).
    - The player who ended the game by emptying their hand scores an additional three **(3) points**.
    - The winners are the players with the highest point total. Ties are permitted.

Additional Option: Memory Games

There are lots of memory games that you can play with this deck of cards. Memory games are best played with only half the deck (30 cards), and the type of memory game you'll be playing depends on how you divide up the deck.

1. Match drugs to their protein targets
The deck includes two copies of each card. Use the numbers **1** and **2** in the bottom left corner to separate the copies so that there are two piles of 30 cards, each with one copy of each card. Set one pile aside and play with the other. It will contain fifteen drug-target pairs that you can try to match.

2. Match drugs
Divide the deck into two piles, one with only drug cards and the other with only protein cards. Set the protein cards aside and play with only the drug cards. There will be two copies of each drug that you can try to match.

3. Match proteins
Divide the deck into two piles, one with only protein cards and the other with only drug cards. Set the drug cards aside and play with only the protein cards. There will be two copies of each protein that you can try to match.

4. Match cards by Type (color)
Simply shuffle the entire deck and use the thirty cards from the top of the deck. You can choose to match cards to cards of the same Type (color) or you could decide to match each Type to its complementary Type (i.e., antibiotic to bacteria, cancer to anticancer, virus to antiviral). There may be some unmatchable cards left over at the end of the game.

How to play memory games

To play, deal the cards you have chosen face down in a 6-by-5 grid. Players take turns flipping pairs of cards face up. If the two flipped cards match, the player may collect them. If they do not match, the player flips them back face down and it is the next player's turn. The game is over when no more cards can be collected. The winners are the players who have collected the most cards. Ties are permitted.

Alternate rule: A player who has collected a matched pair can continue flipping over pairs of cards and collecting matches until they finally flip over an unmatched pair, whereupon their turn ends.

Alternate rule: Cards are initially dealt out face up and all players are given a chance to see them. The cards are then turned face down, and play begins.

6x5 grid for memory games

Protein-Drug Binding Overview

Proteins and their Functions

Proteins are large molecules that perform most of the tasks needed to keep cells alive.

For example, **ribosomes** (which are made of both proteins and RNA) build **new proteins** from **amino acid building blocks** based on instructions provided by an **mRNA template**.

Drugs Disrupt the Tasks of Proteins

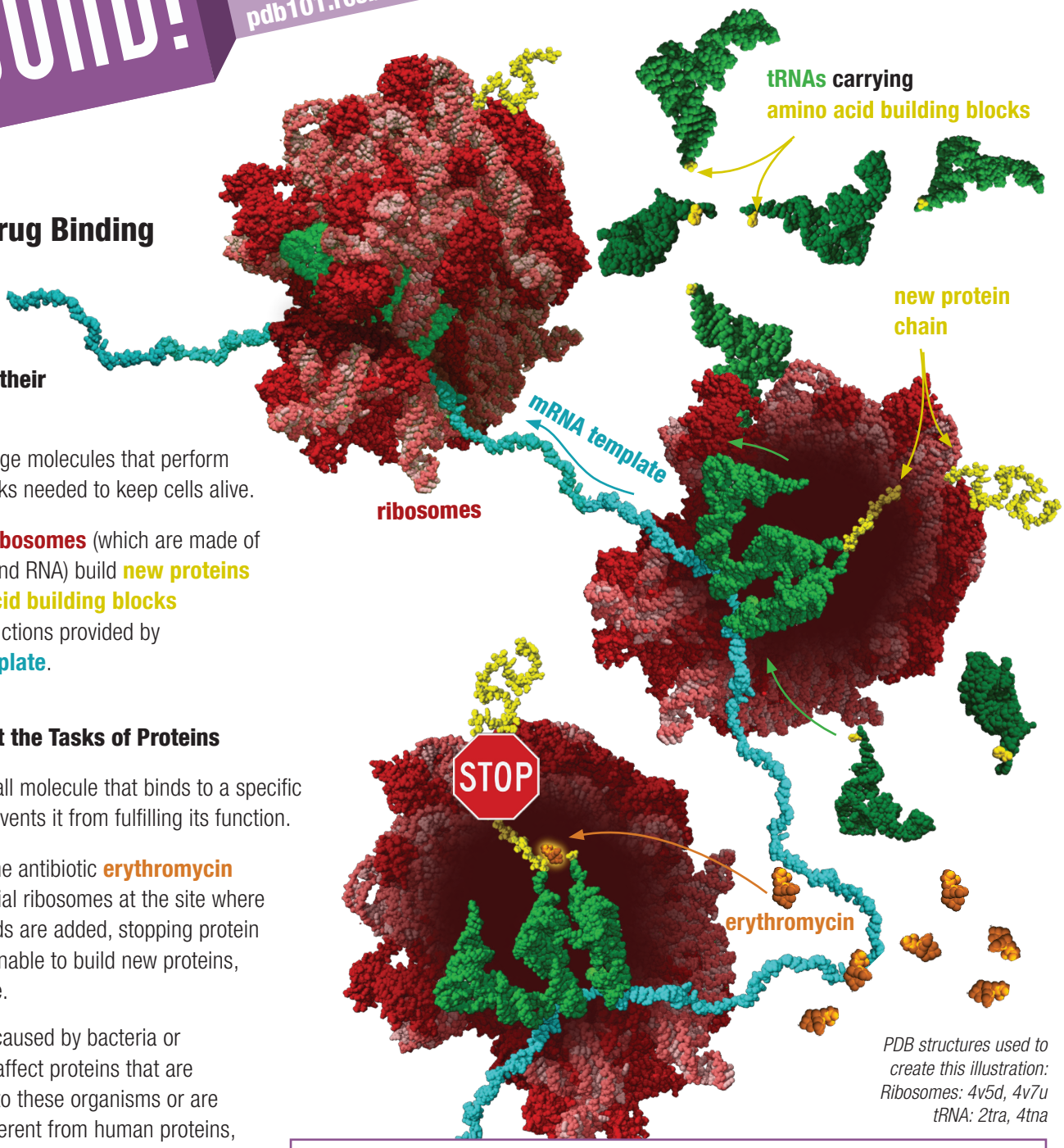
A *drug* is a small molecule that binds to a specific protein and prevents it from fulfilling its function.

For example, the antibiotic **erythromycin** binds to bacterial ribosomes at the site where new amino acids are added, stopping protein construction. Unable to build new proteins, the bacteria die.

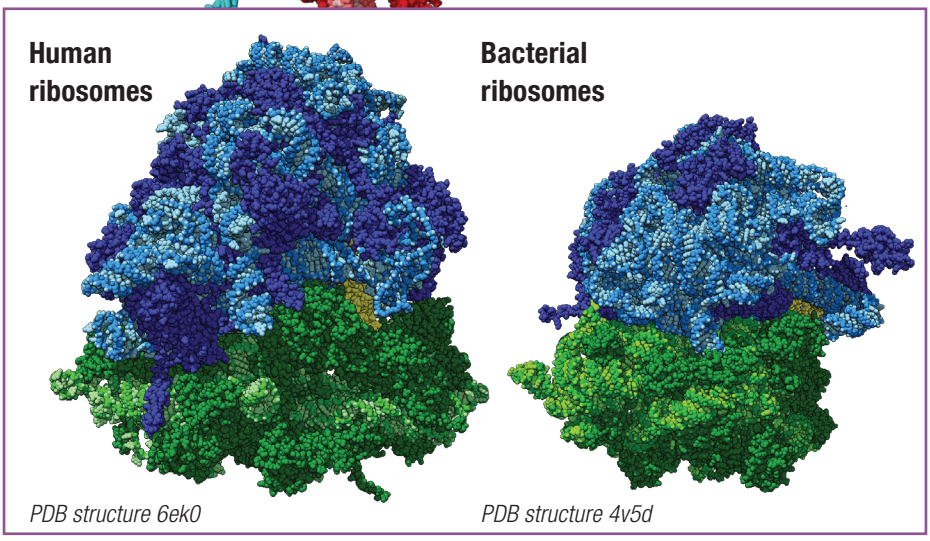
If a disease is caused by bacteria or viruses, drugs affect proteins that are either specific to these organisms or are structurally different from human proteins, so that these antibiotic or antiviral drugs are not also harmful to us.

For example, there are major structural differences between human and bacterial ribosomes that allow us to continue to build new proteins while we are taking erythromycin.

Anticancer drugs block the proteins that are essential for survival of cancer cells, but many also affect proteins in human cells. As a result, many cancer therapies can have severe side effects.



PDB structures used to create this illustration:
Ribosomes: 4v5d, 4v7u
tRNA: 2tra, 4tna



PDB structure 6ek0

PDB structure 4v5d

Accessing More Information on the Proteins and Drugs

This game is a collaboration between two data resources: RCSB Protein Data Bank and the Cambridge Structural Database (CSD), which is curated by the Cambridge Crystallographic Data Centre (CCDC).

About RCSB Protein Data Bank (RCSB PDB) and PDB-101

Cells rely on many large molecular machines that carry out the complex biological and chemical tasks responsible for sustaining life. 3D structures of these machines are freely available at the Protein Data Bank (PDB), the global storehouse of biomolecular structures central to research and education.

RCSB.org serves millions of users worldwide each year, providing services that

- Inform basic and applied research across the sciences
- Are central to understanding human, animal, and plant health and disease
- Are critical for drug discovery/development and biotechnology
- Enable education across biology and medicine
- Funded by NSF (DBI-1832184), DOE (DE-SC0019749), and NIH (R01GM133198)

PDB-101 (**PDB101.rcsb.org**) is the educational portal of the RCSB PDB developed for teachers, students, and the general public to promote exploration in the 3D world of proteins and nucleic acids.

About CSD and CCDC

The Cambridge Structural Database (CSD) is a database of over one million curated crystal structures of organic and metal-organic compounds.

The CSD is curated by the Cambridge Crystallographic Data Centre (CCDC). The CCDC is a registered charity and non-profit organisation committed to the advancement of chemistry for public benefit. At the CCDC, world-leading experts in structural chemistry help shape the future with software and data services that accelerate the discovery and development of new medicines and chemical products.

The CCDC wants to inspire a new generation of structural chemists globally by providing training and educational resources (**www.ccdc.cam.ac.uk/Community/educationalresources**). The resources include:

- Free access to the structures in the CSD via Access Structures on the CCDC website, and free unlimited access to the teaching subset, a set of structures selected for teaching
- Teaching modules for use in classrooms at various levels
- Free Mercury visualisation software
- Fun science activities for kids
- Educational resources for teaching crystallography in undergraduate courses
- Training materials for CCDC tools and features

Learn more about the molecules on these cards

The cards feature two QR codes on the back side.

The code on the upper half links to PDB-101 (**bit.ly/3L76l26**) where you can access information about the protein targets.

The code on the lower half links to CCDC (**bit.ly/37E09Wu**) where you can access more information about the drugs.

This is the PDB access code. To explore the protein in 3D, go to **rcsb.org** and enter the access code into the search bar.

This is the CSD refcode. To explore the drug in 3D, go to **ccdc.cam.ac.uk/structures** and enter the refcode in the identifier bar.