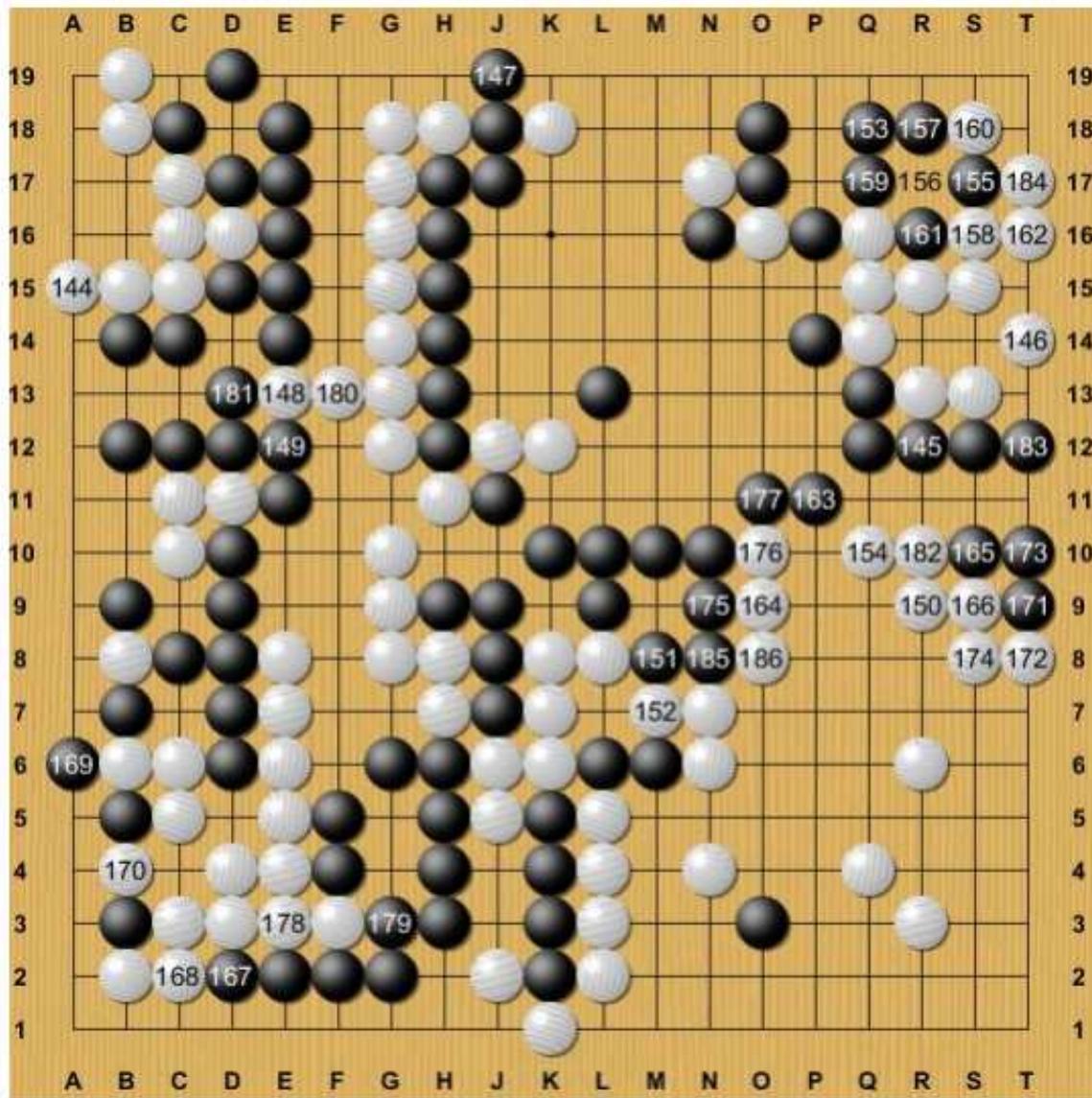


Go Basics

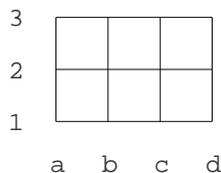
1 Google DeepMind vs Lee Sedol Challenge Match



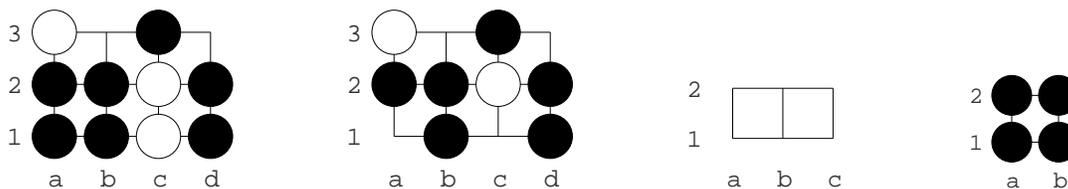
Game 1: LS resigns on move 181. Image © google deepmind <https://www.deepmind.com/research/highlighted-research/alphago/the-challenge-match>

2 Liberties, blocks, and legal positions

A go game has two players: Black has black stones, White has white stones. A go board is a rectangular grid of points. Here is an empty 3×4 board: it has 12 points.



A go *position* is a board with stones on some or none or all points. In a position, points are *adjacent* if they are next to each other in the same row or column. E.g. on a board with at least two rows and at least two columns, the corner point a1 is adjacent to exactly two points, a2 and b1.



For a point with a stone s , the *block* containing s is s together with all stones reachable from s by a path of stones of the same color. (We use the terminology of Martin Müller: a block is a maximal connected set of stones of the go board <https://webdocs.cs.ualberta.ca/~mmueller/ps/gpw97.pdf>. In graph theory lingo, a *block* is a connected component of same-color stones.)

E.g. above, the leftmost position has three black blocks $\{a1, a2, b1, b2\}$, $\{c3\}$, $\{c1, d2\}$, $\{d1, d2\}$ and two white blocks $\{a3\}$, $\{c1, c2\}$. The next position also has three black blocks and two white blocks. The next position has no blocks. The last position has one black block and no white blocks.

For a block, a *liberty* is an empty point that touches the block. E.g. above left, the five blocks as listed above have respective liberties $\{b3\}$, $\{b3, d3\}$, $\{d3\}$, $\{b3\}$, $\{ \}$. A position is *legal* if each block has at least one liberty. E.g. above from left, the positions are illegal, legal, legal, illegal.

Exercise: for the leftmost position above, add or remove exactly one stone so that the new position is legal. Give all correct answers. Justify.

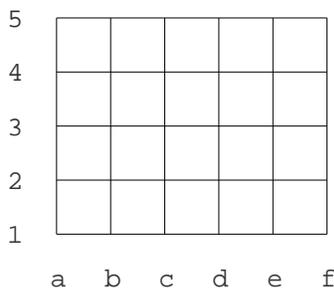
Exercise: for the 2nd-from-left position above, add exactly one stone so that the new position is still legal. Give all correct answers. Justify.

3 Tromp-Taylor go rules

There are many versions of go rules: for example, the go associations of Japan, Korea and China each have their own version. We choose to explain the Tromp-Taylor rules from <http://tromp.github.io/go.html>. These rules are short and precise. No-suicide Tromp-Taylor rules is often used by go programmers. NSTT rules are close to Chinese rules. See also https://en.wikipedia.org/wiki/Rules_of_Go.

rule 1. Go is played on a 19x19 square grid of points, by two players called Black and White.

comment. More generally, go can be played on any $m \times n$ grid of points such as the 5×6 grid below. The grid of points defines what is called a *graph*, namely a set of points and another set giving all adjacent pairs of points. Graphs come up a lot in both math and computing science. Go can be played on any finite graph, e.g. a hexagonal grid or even a non-planar graph.

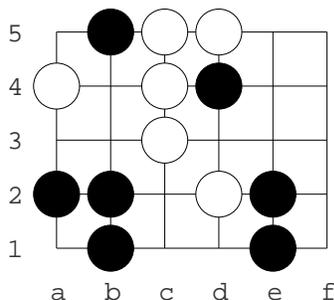


rule 2. Each point on the grid may be colored black, white or empty.

comment. if you place stones instead of coloring points, each point is either a black stones, a white stone, or empty.

rule 3. A point P, not colored C, is said to reach C if there is a path of (vertically or horizontally) adjacent points of P's color from P to a point of color C.

example. Let P be the starting point P (not colored C) and let Q be the destination point (colored C). In the diagram, does b5 reach empty? Does b5 reach white?



Answer: black b5 reaches empty with path ($P = b5, a5 = Q$). Similarly, black b5 reaches white with path ($P = b5, a5, a4 = Q$).

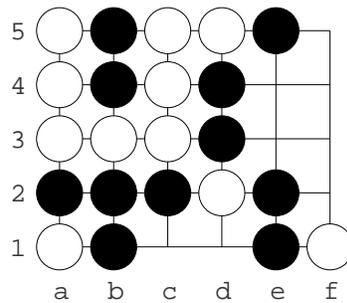
What colors (other than white) does c5 reach? Answer: white c5 reaches black (with $(c5, b5)$ or $(c5, c4, e4)$ or $(c5, d5, e4)$) and empty with any of $(c5, c4, b4)$, $(c5, c4, c3, b3)$, $(c5, c4, c3, c2)$, $(c5, d5, e5)$, $(c5, c4, c3, d3)$.

What colors (other than empty) does b4 reach? Answer: empty b4 reaches black and white.

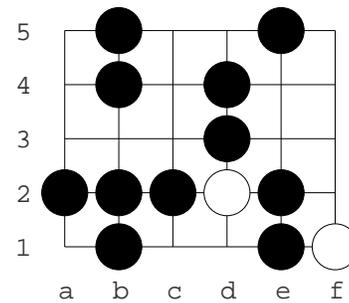
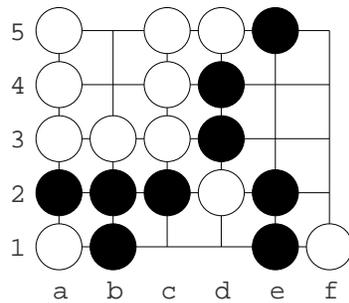
Exercise. for each point P in the diagram, what colors does P reach?

rule 4. Clearing a color is the process of emptying all points of that color that don't reach empty.

comment. An opponent's block is *captured* (removed from the board) when you play a move that takes away its last liberty. Clearing is capturing.

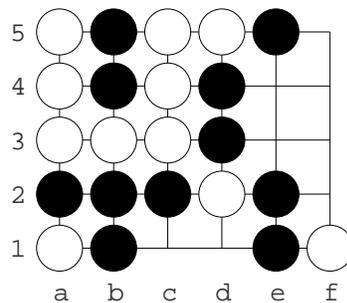


example. Show the board above (a) after clearing black (b) after clearing white.



answer. (a)

(b)



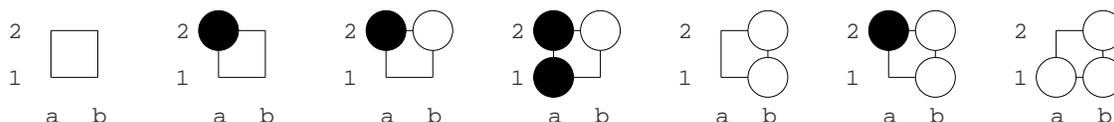
rule 5. Starting with an empty grid, the players alternate turns, starting

with Black.

comment. We saw empty grids earlier.

rule 6. A turn is either a pass or a move that doesn't repeat an earlier grid coloring.

comment. We call grid colorings *positions*. A repeat of a previous coloring is *superko*: this rule forbids superko of positions, called *positional superko*. E.g. the game below started 1.B[a2] 2.W[b2] 3.B[a1] 4.B[b1] 5.B[a2] 6.W[a1]. By rule 6, Black cannot play 7.B[a2]: this captures the white block and recreates the position after 1.B[a2].



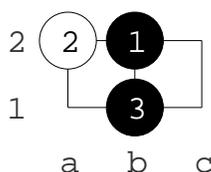
rule 7. A move consists of coloring an empty point one's own color; then clearing the opponent color, and then clearing one's own color.

comment 7a. Rule 7 can be rephrased: a move consists of putting a stone on an empty point, then removing any captured opponent blocks, and then removing any captured blocks of one's own.

comment 7b. Removing a captured block of one's own is called *suicide*. The Tromp-Taylor rules allow suicide: many rules sets do not. Chinese rules are essentially no-suicide Tromp-Taylor rules.

comment 7c. For any fixed move, at most one of the two clearing processes can have effect: if a move captures an opponent block, then the placed stone will have at least one liberty and suicide is not possible; if a move results in suicide, then the stone is placed in the last liberty of a player's group, so the placed stone has no adjacent empty cell, so no opponent block was captured.

E.g. in the game below, if players follow Tromp-Taylor rules, move 4.W[a1] is suicide: after White places a stone at a1, the black block still has liberties and is not captured, so the white block at {a1,a2} has no liberties and is removed from the board. If the players follow No-Suicide Tromp-Taylor rules, 4.W[a1] is illegal: White's only options for move 4 are 4.W[c1], 4.W[c2], or pass. Unless we say otherwise, we assume NSTT rules.

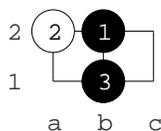


rule 8. The game ends after two consecutive passes.

comment. In practise, players usually end the game once they both agree what the final score will be if they keep playing: this happens when they agree on which blocks will be dead at the end of the game.

rule 9. A player's score is the number of points of her color, plus the number of empty points that reach only her color.

comment. This is *area scoring*. Japanese rules use *territory scoring*, which gives points for opponent stones captured. In most games, area scoring and territory scoring differ by at most 1.



E.g. assume that the game above continues with two consecutive passes: what is the final Tromp-Taylor score?

Answer: Black has 2 stones and 2 territory points, White has 1 stone and 0 territory points, so Black wins by 3 points.

What is the final score if both players agree that the white stone at a2 is dead?

Answer: Black wins by 6 points.

If both players continue this game perfectly (i.e. score the best they can, taking into account every possible opponent strategy), then what will the final score in this game be?

Answer: Black can kill all White blocks: Black wins by 6.

rule 10. The player with the higher score at the end of the game is the winner. Equal scores result in a tie.

E.g. in the 2x2 game above, Black has no legal play on move 7 and so passes. Now White can pass, so the final score is Black has no stones and no territory points, White has 3 stones and 1 territory point, so White wins by 4 points.

4 komi

Between players of equal strength, in order to offset Black's first-player advantage, an extra number of points called the *komi* is added to White's score at the end of the game. The komi is agreed to by the players before the game starts. In the AG-LS match, the board size was 19x19 and the komi was 7.5. Using a non-integer komi guarantees that White's final score will be some integer plus a non-integer, so the game will not end in a draw.

5 time control

In tournament games, each player has a limited amount of time to make their moves. In the AG-LS match, each player had 2 hours and 3 60-second *byoyomi* (Japanese: counting seconds) intervals. As soon as a player has used up their allotted time (2 hours), the 60-second byoyomi clock starts: if they make their move before the 60 seconds passes, then they do not lose the byoyomi, and it will reset to 60 seconds on their next move. If they have not made their move after the 60 seconds, they lose that byoyomi and either they lose on time if that was their last byoyomi, or their next byoyomi clock starts.

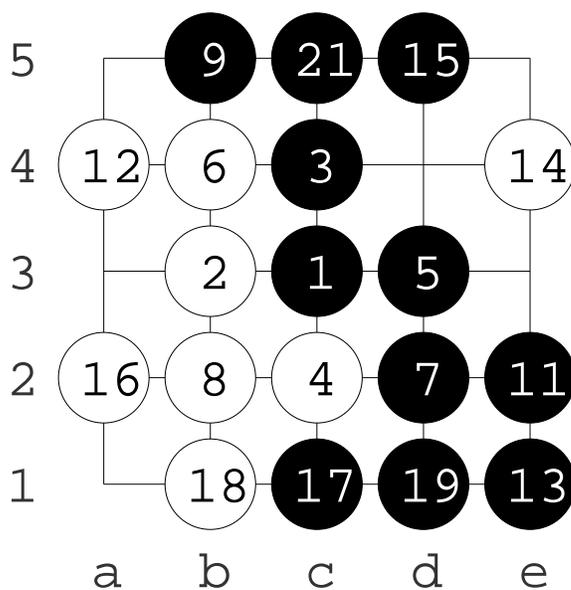
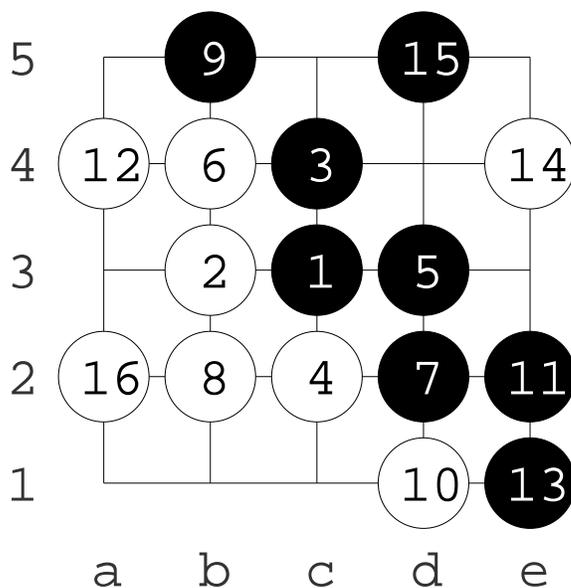
6 player ranking

Beginners start at around 30 kyu, and as they get stronger, their kyu ranking goes down. The idea is players whose ranks differ by t will have an even game if the weaker player starts with t stones on the board. After 1 kyu, the next stronger rank is 1 dan. Amateur ranks stop at 9 dan.

Professional ranks start at 1 dan, written 1p. These ranks are assigned the player's professional go association, and go up to 9p. A 1 dan professional is much stronger than a 1 dan amateur. Lee Sedol turned pro at age 12 and was awarded 9p status at age 23.

7 sample game against Cosumi

Here is a game against Cosumi. We play first, Cosumi is second.



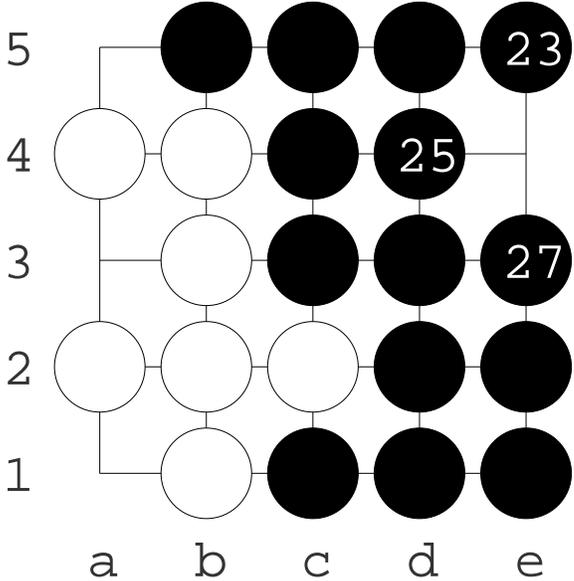
What is the Tromp-Taylor score if both players now pass? 11 stones and 0 points territory for Black, 8 stones and 2 points territory for White, so Black wins by 1 point.

What does Cosumi say the score is? White wins by 27 points! Why?

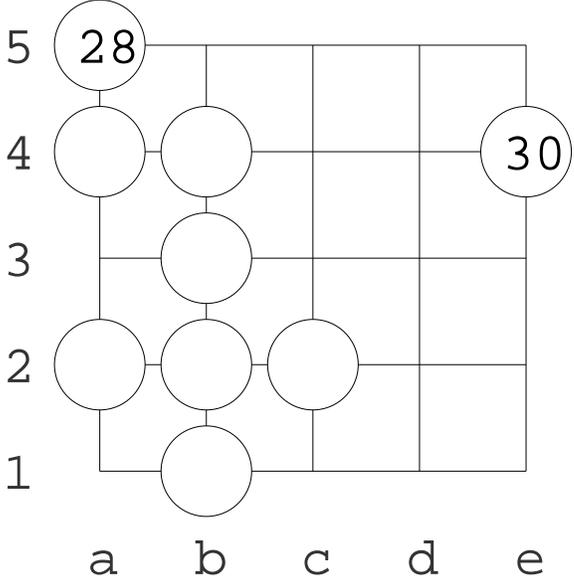
Two reasons: Cosumi scores using Japanese rules (we won't cover them in this class, but you lose points when a stone is captured; with TT rules, the most you can lose by is the number of points on the board; with Japanese rules, you can do worse!); and Cosumi assumes that a player stops playing in any region that the opponent can

capture. In this game, no matter how Black continues, White can capture all the Black stones on the board, so that the final TT score will be that White wins by 25.

Here's why. Suppose White keeps passing and the game continues as below, with Black capturing the white stone at e4.

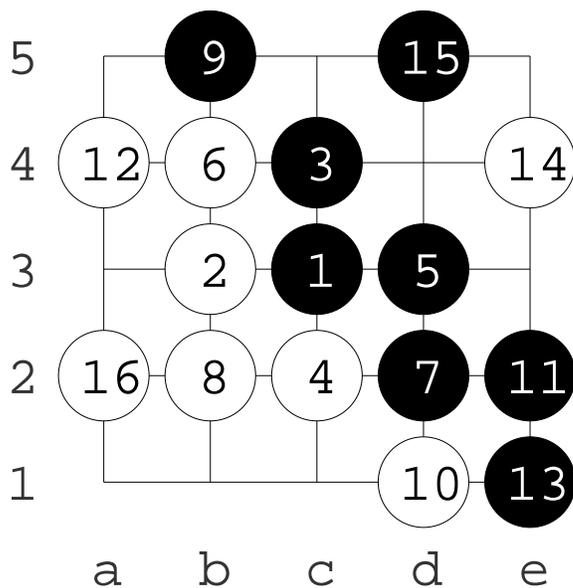


Then White can take a5 and then *snap back* at e4, capturing the whole Black group!



It takes some time to check all possible ways that Black can play from here, but it is an easy task for White to make sure that the game ends with no black stones on the board. Cosumi saw this earlier.

So where did Black go wrong in this game?



13.B[e1] was a terrible blunder. If instead 13.B[e4] then the black stones can all be saved.

3.B[c3] was also a mistake: if instead 3.B[b4] then with careful play Black can win by 25 points.

Below is a better opening for Black.

