Long Cycle Positions

by Robert Jasiek, 2006-09-05

Preface

This broad, but of course not complete selection of shapes and positions concentrates on those where long cycles are or might be interesting. Analysis is done for game end and scoring rules as in the Unified Area Rules and the following ko rules:

- A play may not remove a single stone if this stone has removed a single stone in the preceding play.
- If a play creates a cycle, then the game's result depends on the numbers of black and white stones removed from the board during the cycle: a) If equally many black and white stones have been removed, then the result is a tie. b) If fewer black than white stones have been removed, then the result is a Black win. c) If fewer white than black stones have been removed, then the result is a White win.

Some of the non-traditional shapes or positions have been discovered by other persons. To shorten this document, their names are mentioned only elsewhere. - This document concentrates on ko rules and does not show all possible variations of different applications of game end rules. - Statistics are imprecise and vary considerably but as a lower bound one can say: A special rare shape like double-ko-seki or triple-ko occurs in less than one of 3,500 games. - Where shapes are assigned names, these are traditional. They are not meant to imply any particular strategic behaviour. E.g., a so called dead-ko might survive to the game end. - The position index numbers conform to the author's database and hence appear a little arbitrary in this document.

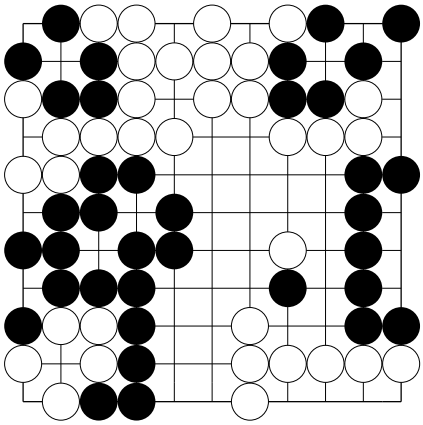
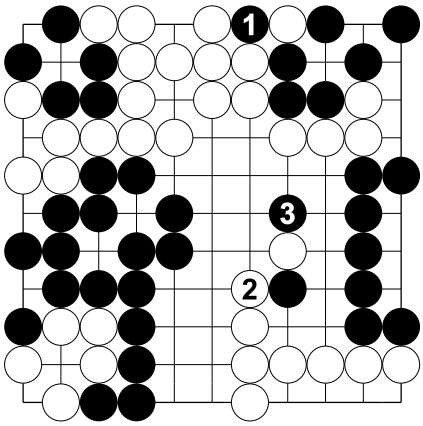
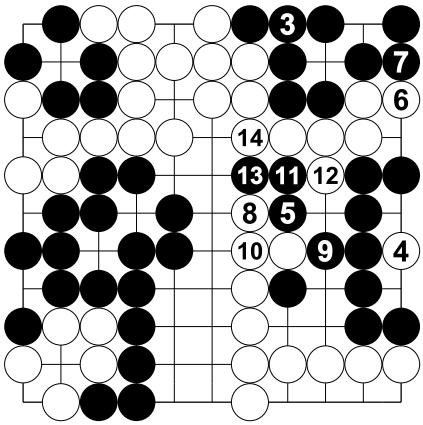
As far as the author knows, all historical games with cycles were caused by special shapes being involved: double-ko-seki, double-ko-semeai, triple-ko, quadruple-ko, eternal-life, etc. When this is being written, it is still an open theoretical problem if a position with several separate basic-kos and a forced cycle exists. Therefore such an example cannot be given here. Probably it would behave like an n-tuple-ko.

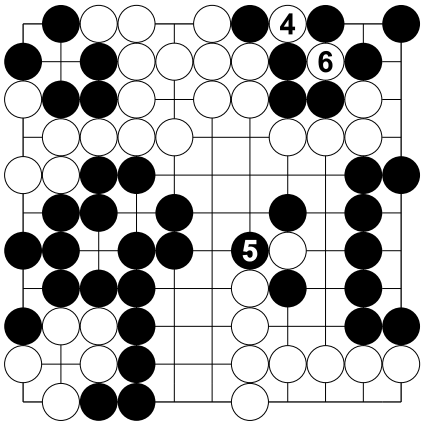
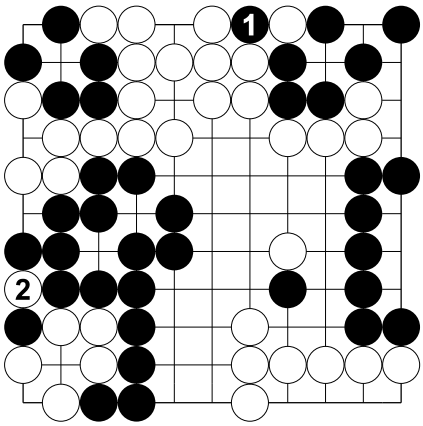
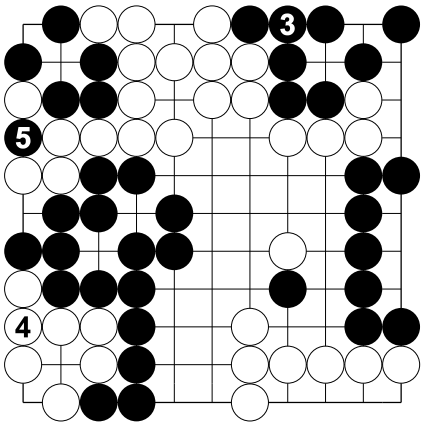
Colours have the following meanings:

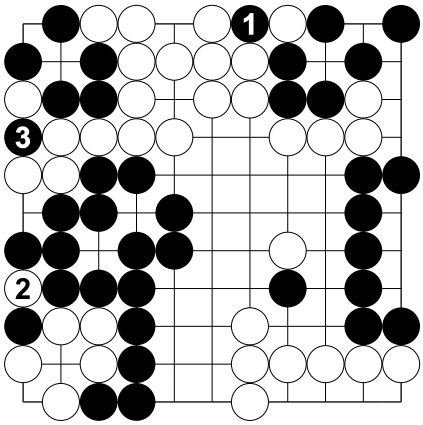
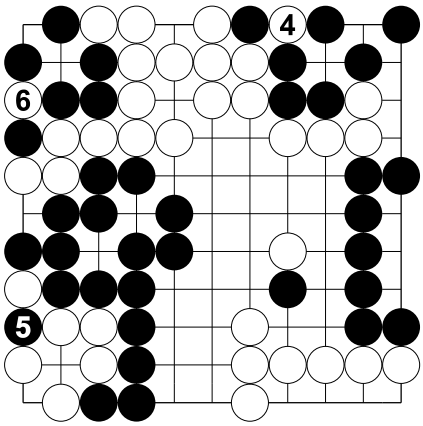
- Blue: Necessarily perfect play leads to a cycle.
- Red: A cycle occurs only after a strategic mistake.
- Lilac: A cycle is possible but not forced.

Removals Difference Zero

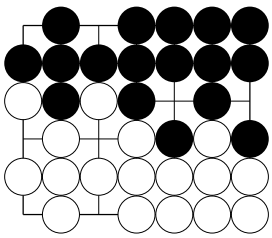
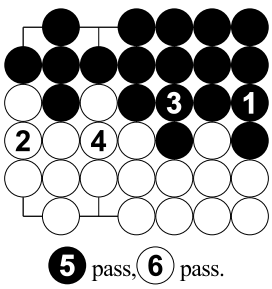
Basic-kos during the Middle Game

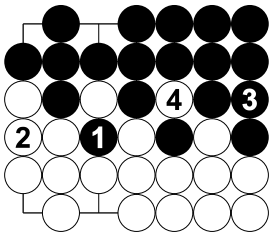
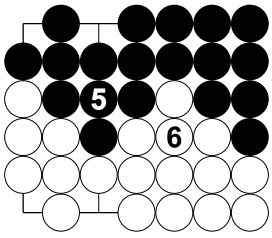
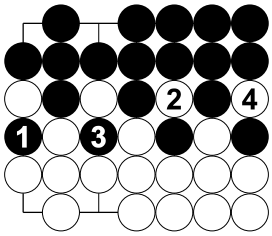
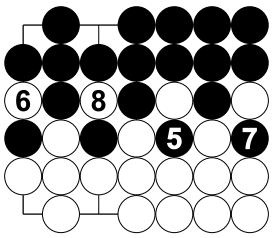
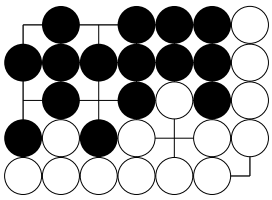
	**Position 0090**, Black to move. A cycle does not occur in perfect play. Note: In most middle game positions with several basic-kos, one of them is the biggest and the others are left until later. In this idealized position, the two basic-kos on the left are equal options.
	*Variation 1:* Should the players fight the biggest basic-ko?
	*Variation 1a:* This might happen if Black 3 tries to ignore the ko threat 2.

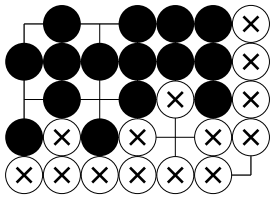
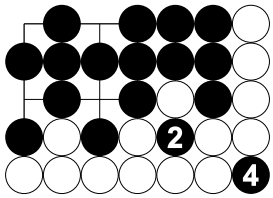
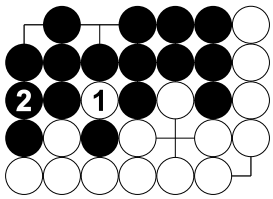
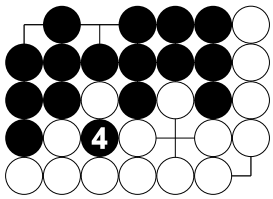
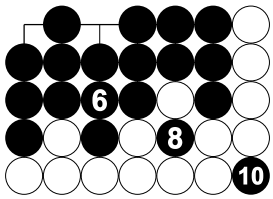
	*Variation 1b:* Continuing variation 1, White wins the upper right basic-ko while Black gets only small endgame. White is going to win the game.
	*Variation 2:* Move 2 is a strategic mistake.
	White might have won the biggest basic-ko. Now he has to win one of the smaller basic-kos. I.e. White has already suffered from a loss. This would have been similar if White 2 had connected the upper left basic-ko.

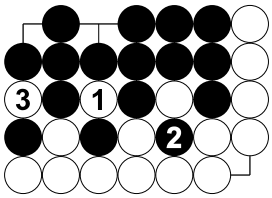
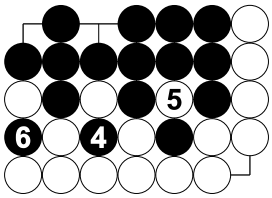
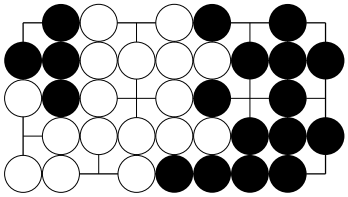
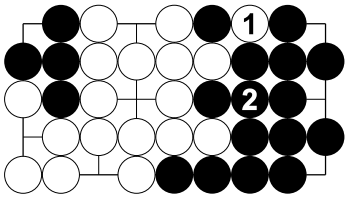
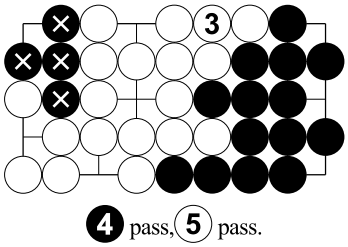
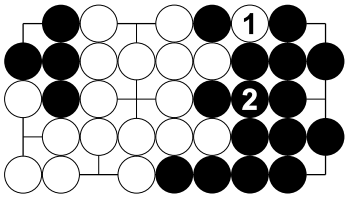
	*Variation 3:* Plays 2, 3, and 6 are strategic mistakes. Both players might create a cycle. Thereby White throws away his game win. Black's cooperation is trick play.
	Play 6 creates a cycle. The long-cycle-rule applies. During the cycle 3 black and 3 white stones have been removed from the board. Their difference is zero. Result = tie.

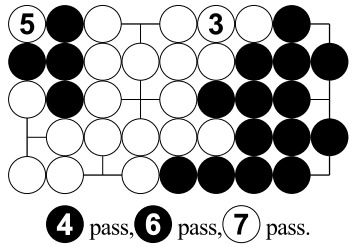
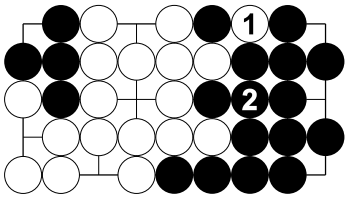
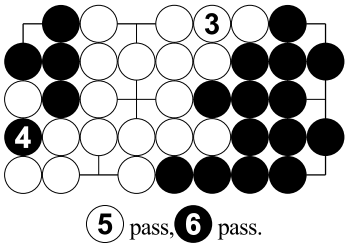
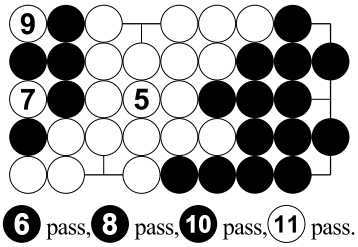
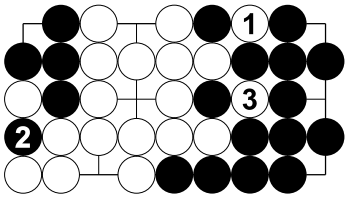
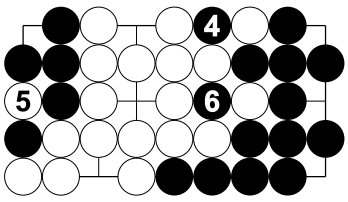
Basic-kos during the Endgame

	**Position 0081**, Black to move, komi = 0.5. A cycle does not occur in perfect play.
	*Variation 1:* This is a possible perfect play. Score = -0.5. Result = White win. Notes: There are many variations that are perfect play. To be sure that all are perfect play, one has to either read ahead many variations or refer to a mathematical proposition that proves correct strategy and score. Such advanced strategic theory, however, is beyond the scope of this document.

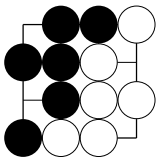
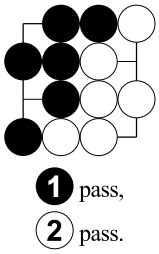
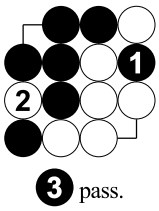
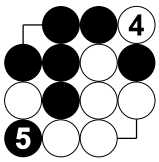
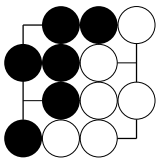
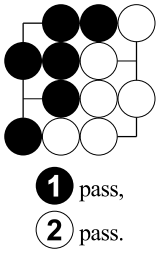
	*Variation 2:* This is a possible perfect play.
 7 pass, 8 pass.	Score = -0.5. Result = White win.
	*Variation 3:* Play 8 is a strategic mistake.
	Play 8 creates a cycle. The long-cycle-rule applies. During the cycle 4 black and 4 white stones have been removed from the board. Their difference is zero. Result = tie.
	**Position 0033**, White to move, komi = 0. A cycle does not occur in perfect play.

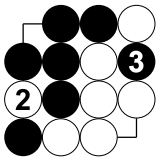
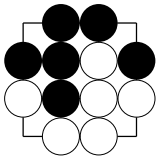
 (1) pass, (2) pass.	*Variation 1:* This is a possible perfect play. During the Agreement Phase after move 2, the players agree to remove the marked stones. Score = 35. Result = Black win.
 (1) pass, (3) pass, (5) pass, (6) pass.	*Variation 2:* This is a possible perfect play. Score = 35. Result = Black win.
 (3) pass.	*Variation 3:* This is a possible perfect play.
 (5) pass.	
 (7) pass, (9) pass, (11) pass, (12) pass.	Score = 35. Result = Black win.

	*Variation 4:* Play 6 is a strategic mistake.
	Play 6 creates a cycle. The long-cycle-rule applies. During the cycle 3 black and 3 white stones have been removed from the board. Their difference is zero. Result = tie.
	**Position 0037**, White to move, komi = 0. A cycle does not occur in perfect play.
	*Variation 1:* This is a possible perfect play.
	During the Agreement Phase after move 5, the players agree to remove the marked stones. Score = -11. Result = White win.
	*Variation 2:* This is a possible perfect play.

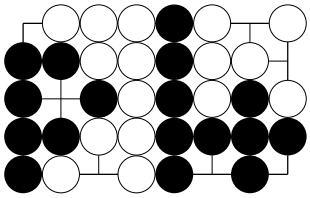
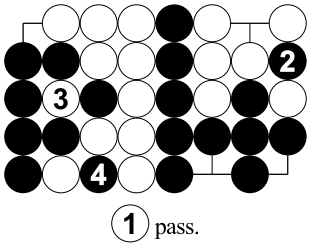
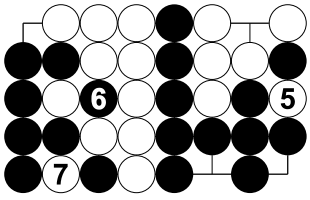
	Score = -11. Result = White win.
	*Variation 3:* Ending the game by passing is not enough for removing a dead-ko. White makes a strategic mistake.
	If the players end the game like this, then we have: Score = 3. Result = Black win.
	*Variation 3a:* This is a possible perfect play. Filling territory serves as a ko threat. Score = -11. Result = White win. Notes: On the 19x19 board, it is inconceivable that such a ko threat would not be available in practice. Only in theory, a dead-ko might survive at the game end. During the entire Go history, only one such 9x9 game has been reported.
	*Variation 4:* Play 5 is a strategic mistake.
	Play 6 creates a cycle. The long-cycle-rule applies. During the cycle 3 black and 3 white stones have been removed from the board. Their difference is zero. Result = tie.

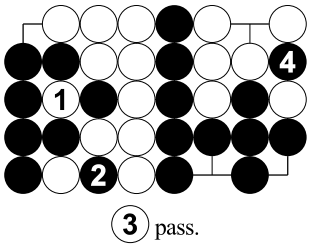
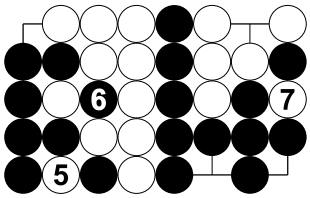
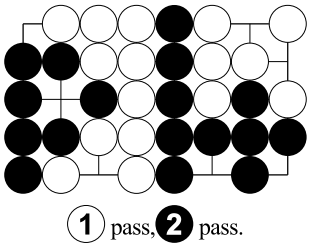
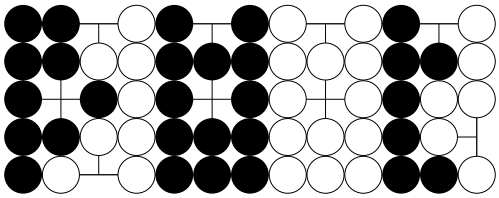
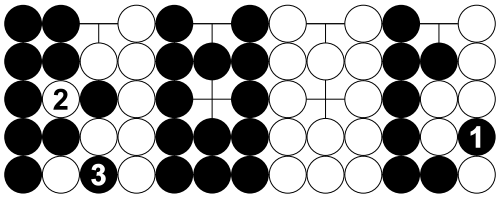
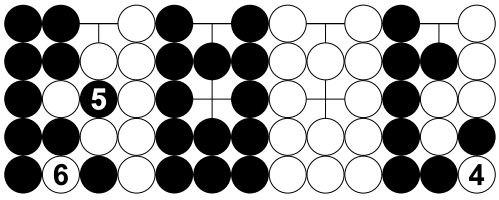
Double-ko-seki

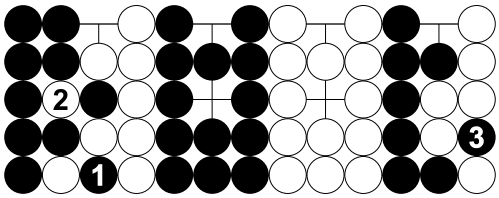
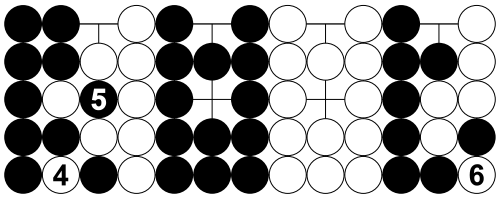
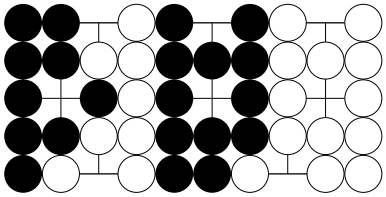
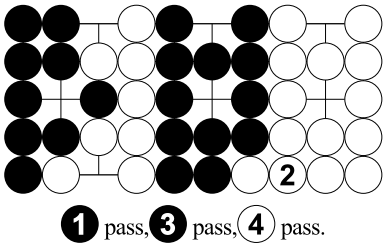
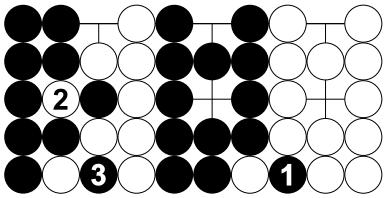
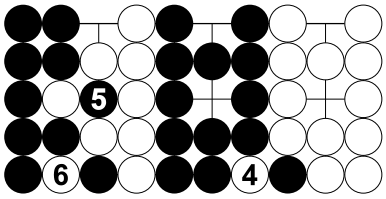
	**Position 0055**, Black to move, komi = 0. A cycle occurs only if the players cooperate.
	*Variation 1:* This is a possible perfect play. Score = 0. Result = tie.
	*Variation 2:* This is a possible perfect play. Both players cooperate to create a long-cycle-tie.
	Play 5 creates a cycle. The long-cycle-rule applies. During the cycle 2 black and 2 white stones have been removed from the board. Their difference is zero. Result = tie.
	**Position 0055**, Black to move, komi = -0.5. A cycle does not occur in perfect play.
	*Variation 1:* This is a possible perfect play. Score = 0.5. Result = Black win.

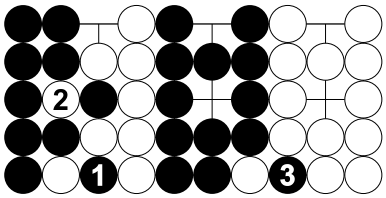
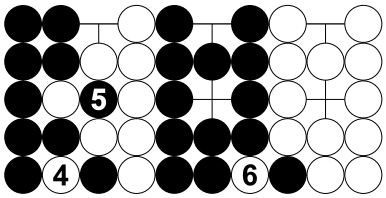
 1 pass, 4 pass, 5 pass.	*Variation 2:* This is a possible perfect play. At move 5, Black prefers to pass so that a cycle will not be created. Score = 0.5. Result = Black win.
 6 pass, 7 pass.	*Variation 2a:* If after an Agreement Phase the alternation continues, then this is a possible perfect play. At move 6, due to the basic-ko-rule White may not recapture the stone 3 because of the preceding play 3. White cannot force a long-cycle-tie. Score = 0.5. Result = Black win.

Double-ko-seki and Other Ko(s)

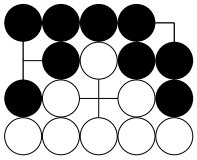
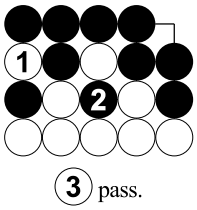
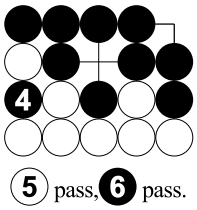
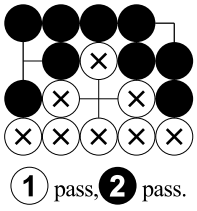
	**Position 0047**, White to move, komi = 7.5. A cycle occurs in perfect play.
 1 pass.	*Variation 1:* This is a possible perfect play.
	Play 7 creates a cycle. The long-cycle-rule applies. During the cycle 3 black and 3 white stones have been removed from the board. Their difference is zero. Result = tie.

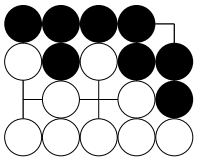
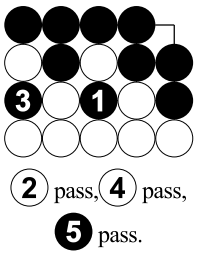
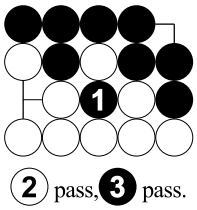
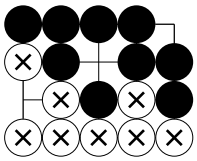
	*Variation 2:* This is a possible perfect play.
	Play 7 creates a cycle. The long-cycle-rule applies. During the cycle 3 black and 3 white stones have been removed from the board. Their difference is zero. Result = tie.
	*Variation 3:* Move 2 is a strategic mistake. Score = -6.5. Result = White win.
	**Position 0091**, Black to move, komi = 0. A cycle occurs in perfect play.
	*Variation 1:* This is a possible perfect play.
	Play 6 creates a cycle. The long-cycle-rule applies. During the cycle 3 black and 3 white stones have been removed from the board. Their difference is zero. Result = tie.

	*Variation 2:* This is a possible perfect play.
	Play 6 creates a cycle. The long-cycle-rule applies. During the cycle 3 black and 3 white stones have been removed from the board. Their difference is zero. Result = tie.
	**Position 0159**, Black to move, komi = 0. A cycle occurs in perfect play.
	*Variation 1:* Move 1 is a strategic mistake. Score = -1. Result = White win.
	*Variation 2:* This is a possible perfect play.
	Play 6 creates a cycle. The long-cycle-rule applies. During the cycle 3 black and 3 white stones have been removed from the board. Their difference is zero. Result = tie.

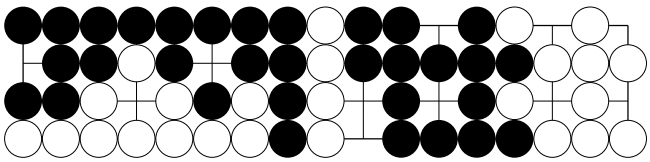
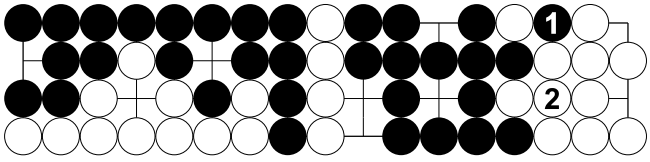
	*Variation 3:* This is a possible perfect play.
	Play 6 creates a cycle. The long-cycle-rule applies. During the cycle 3 black and 3 white stones have been removed from the board. Their difference is zero. Result = tie.

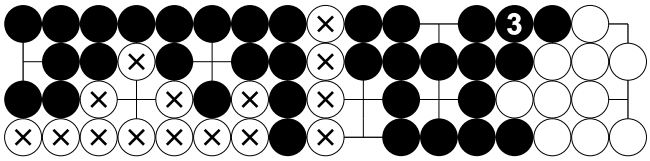
Double-ko-death

	**Position 0056**, White to move. A cycle does not occur in perfect play.
	*Variation 1:* This is a possible perfect play. White's attack is futile.
	Score = 20. Result = Black win.
	*Variation 2:* This is a possible perfect play. During the Agreement Phase after move 2, the players agree to remove the marked stones. Score = 20. Result = Black win.

	**Position 0075**, Black to move. A cycle does not occur in perfect play.
	*Variation 1:* This is a possible perfect play. Score = 20. Result = Black win.
	*Variation 2:* This is a possible perfect play.
	During the Agreement Phase, the players agree to remove the marked stones. Score = 20. Result = Black win.

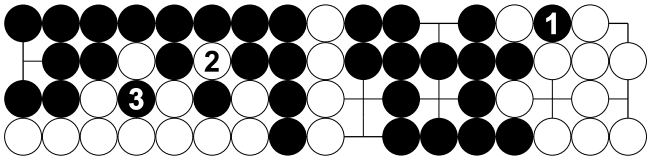
Double-ko-death and Other Ko(s)

	**Position 0082**, Black to move, komi = 40.5. A cycle does not occur in perfect play.
	*Variation 1*: This is a possible perfect play.

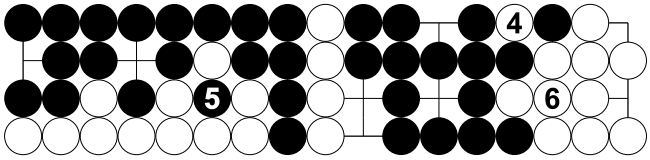


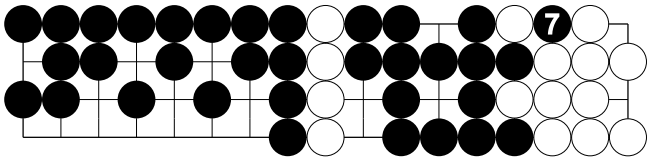
④ pass, ⑤ pass.

During an Agreement Phase after move 5, the players agree to remove the marked stones. Score = 3.5. Result = Black win.

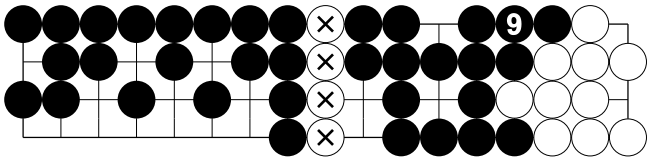


Variation 2: This is a possible perfect play. Despite the double-ko-death White cannot win both endgame kos.



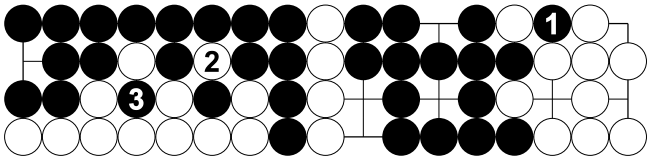


⑧ pass.

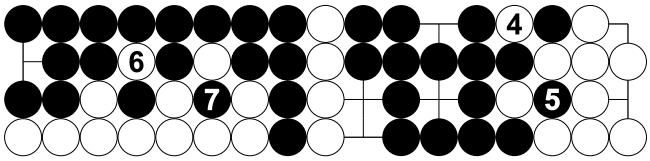


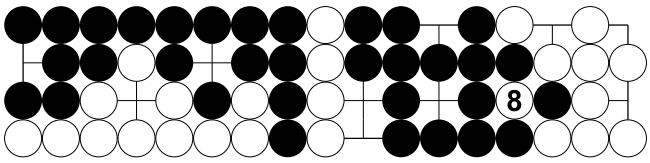
⑩ pass, ⑪ pass.

During an Agreement Phase after move 11, the players agree to remove the marked stones. Score = 3.5. Result = Black win.

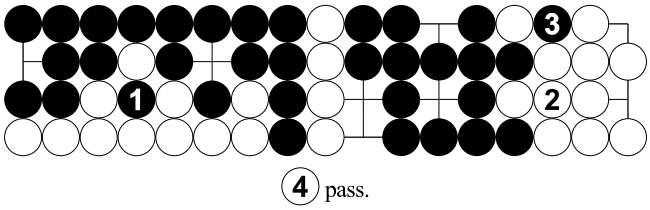


Variation 3: Move 5 is strategic mistake.

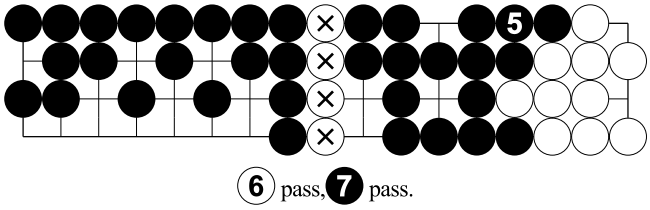




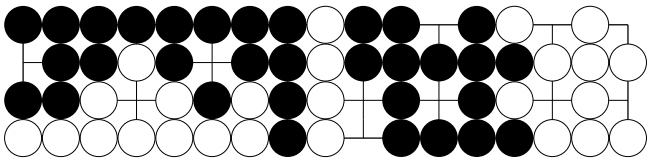
Play 8 creates a cycle. The long-cycle-rule applies. During the cycle 4 black and 4 white stones have been removed from the board. Their difference is zero. Result = tie.



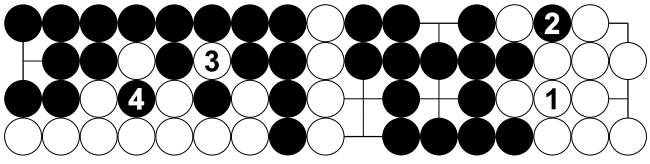
Variation 4: This is a possible perfect play.



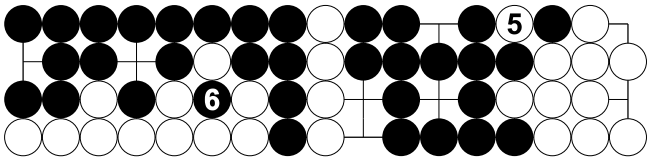
During an Agreement Phase after move 7, the players agree to remove the marked stones. Score = 3.5. Result = Black win.

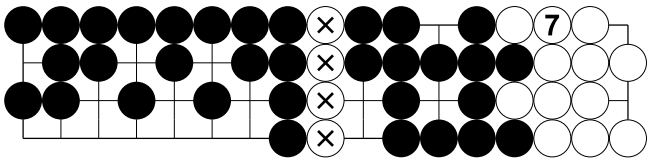


Position 0082, White to move, komi = 40.5. A cycle does not occur in perfect play.



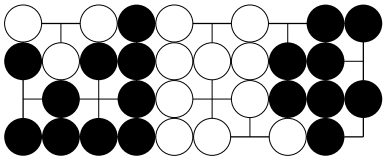
Variation 1: This is a possible perfect play. White is said to have an arbitrary number of ko threats in the double-ko-death.



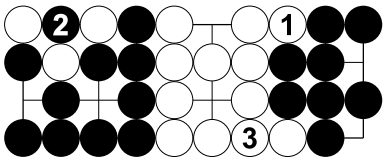


8 pass, 9 pass.

During an Agreement Phase after move 9, the players agree to remove the marked stones. Score = -0.5. Result = White win.

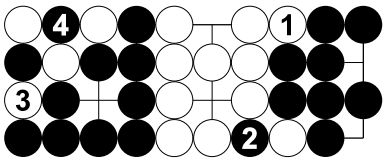


Position 0095, White to move, komi = 12.5.
A cycle does not occur in perfect play.

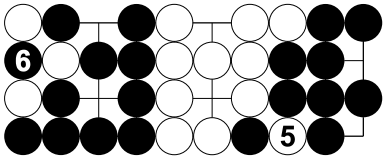


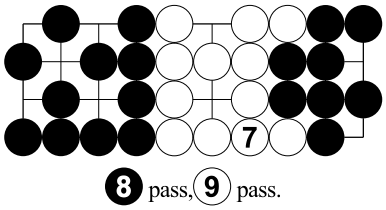
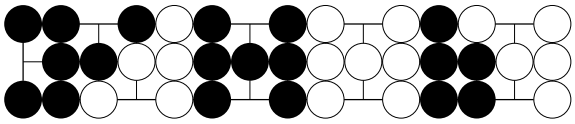
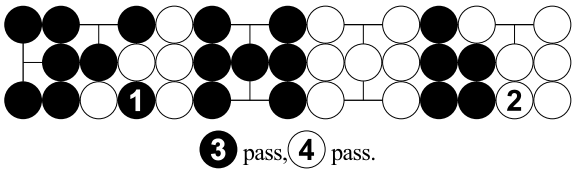
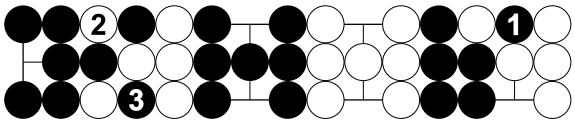
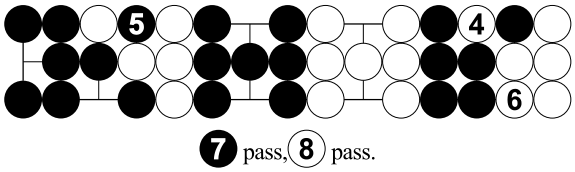
4 pass, 5 pass.

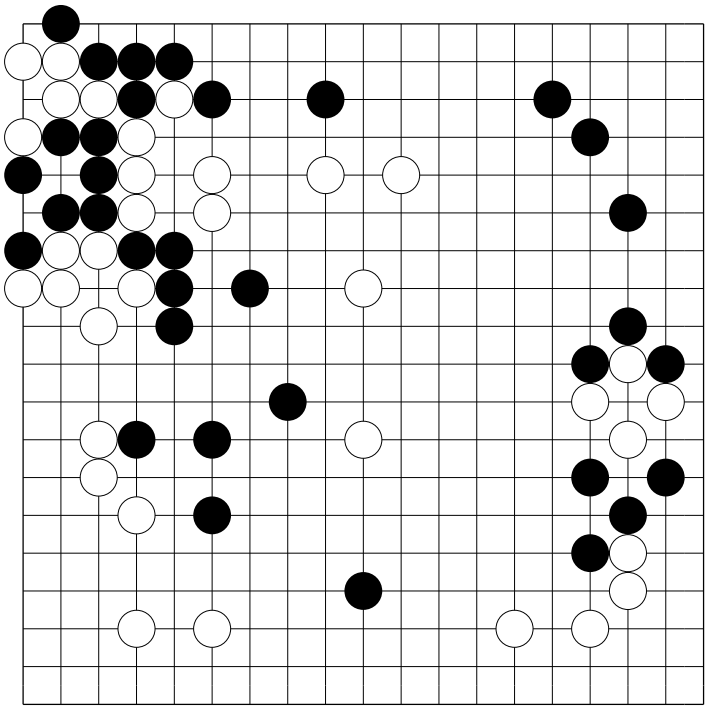
Variation 1: This is a possible perfect play.
Score = -0.5. Result = White win.



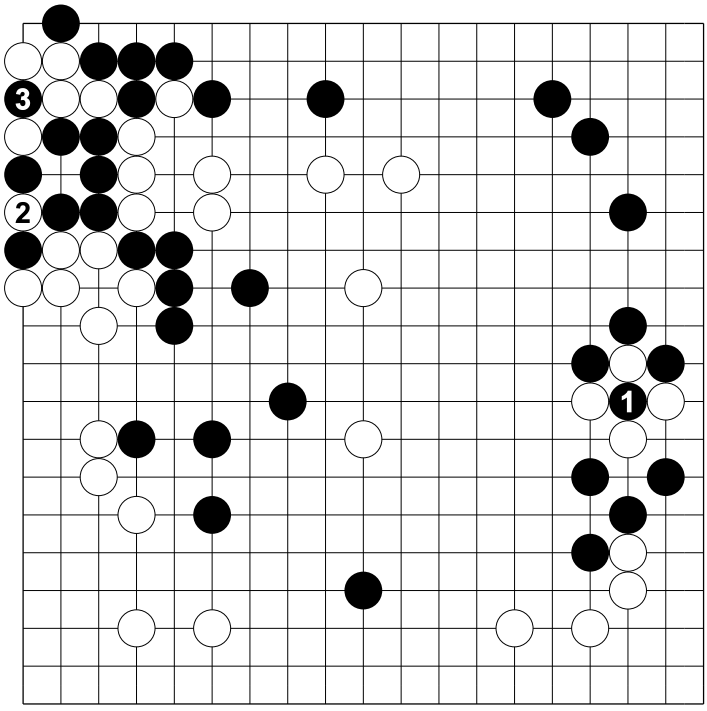
Variation 2: This is a possible perfect play.



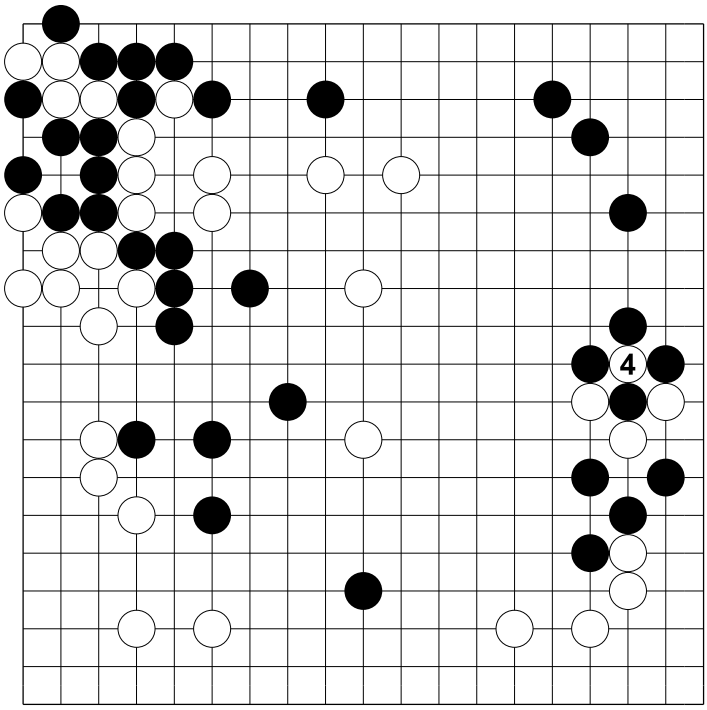
	Score = -0.5. Result = White win.
	**Position 0096**, Black to move. A cycle does not occur in perfect play.
	*Variation 1:* This is a possible perfect play. Score = 3. Result = Black win.
	*Variation 2:* This is a possible perfect play.
	Score = 3. Result = Black win.



Position 0097, Black to move. A cycle does not occur.

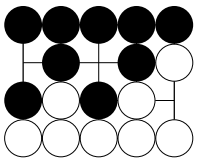
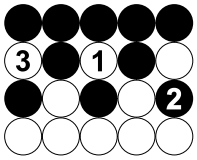
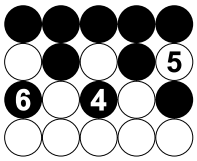


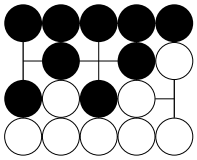
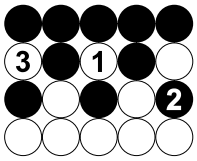
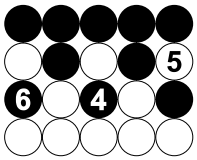
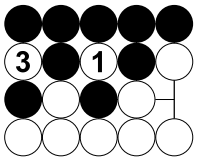
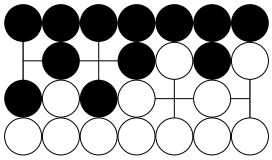
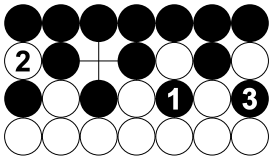
Variation 1: White uses his so called supply of arbitrarily many ko threats in the double-ko-death.

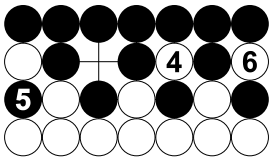
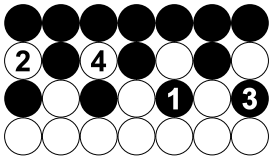
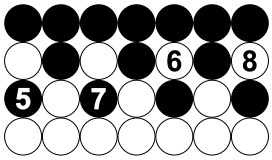
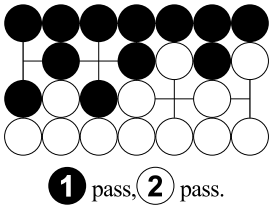
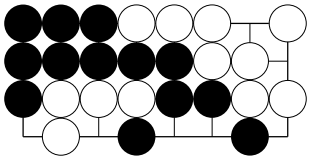
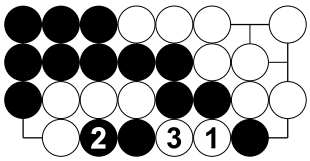
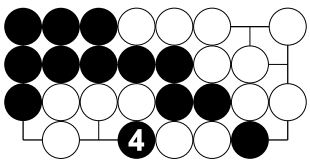


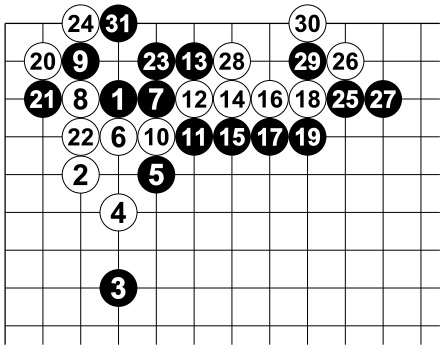
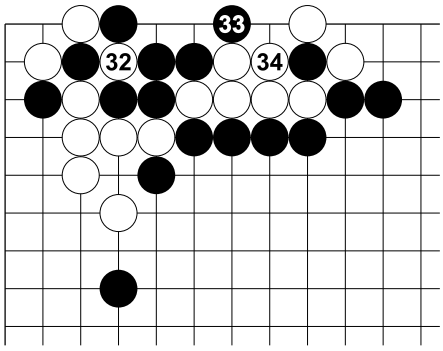
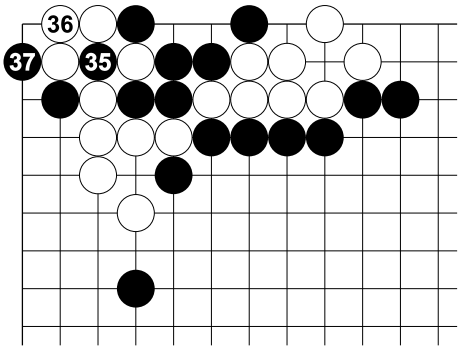
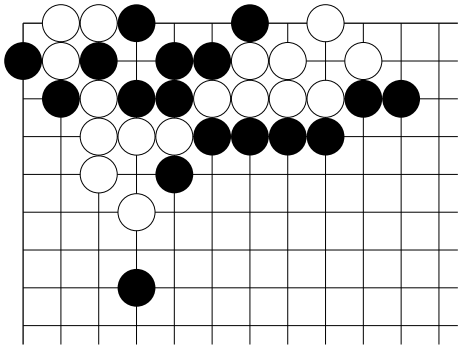
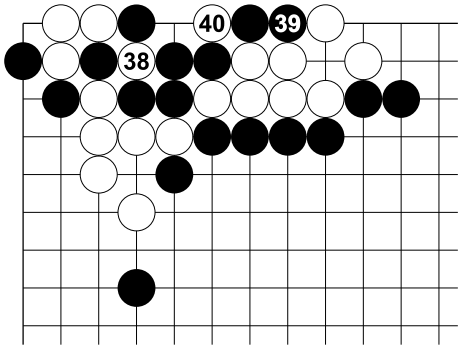
If Black tries to fight the basic-ko on the right side, he does not have ko threats in the double-ko-death. Therefore a cycle will not be created in typical strong play.

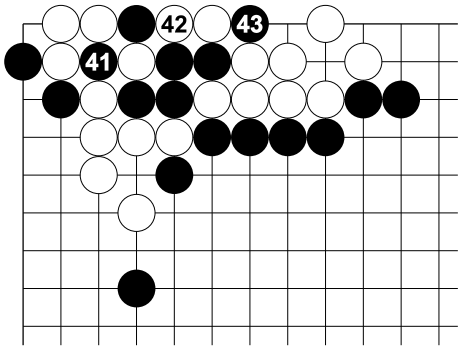
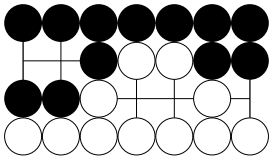
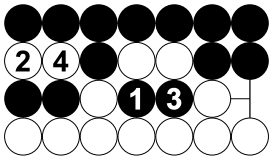
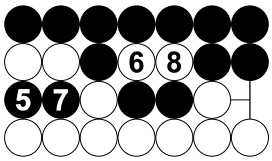
Frequently Studied Other Traditional Rare Shapes

	**Position 0049**, White to move, komi = 0. A cycle occurs in perfect play.
	*Variation 1:* This is a possible perfect play.
	Play 6 creates a cycle. The long-cycle-rule applies. During the cycle 3 black and 3 white stones have been removed from the board. Their difference is zero. Result = tie.

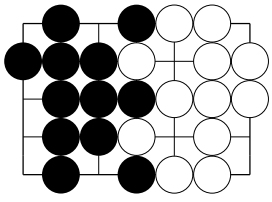
	**Position 0049**, White to move, komi = -20.5. A cycle does not occur in perfect play. Notes: Also in other long cycle shapes, a player might consider winning the game by sacrificing the local shape. It is not a local shape alone that causes a cycle. In particular, the global position and the komi have to be considered for correct strategy, too.
	*Variation 1:* Move 6 is a strategic mistake.
	Play 6 creates a cycle. The long-cycle-rule applies. During the cycle 3 black and 3 white stones have been removed from the board. Their difference is zero. Result = tie.
	*Variation 2:* This is a possible perfect play. Score = 0.5. Result = Black win.
	**Position 0109**, Black to move, komi = 0. A cycle can occur in perfect play when either player forces his opponent to create a cycle.
	*Variation 1:* This is a possible perfect play.

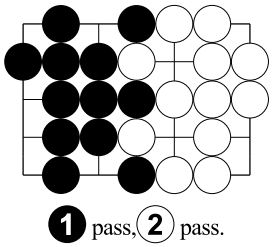
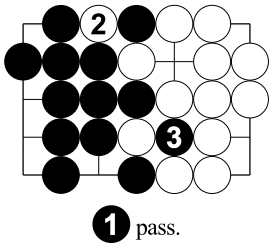
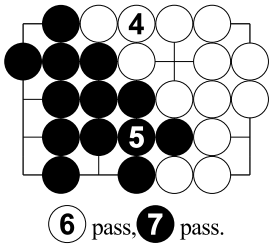
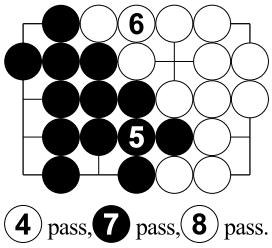
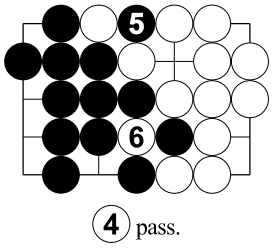
	Play 6 creates a cycle. The long-cycle-rule applies. During the cycle 3 black and 3 white stones have been removed from the board. Their difference is zero. Result = tie.
	*Variation 2:* This is a possible perfect play.
	Play 8 creates a cycle. The long-cycle-rule applies. During the cycle 4 black and 4 white stones have been removed from the board. Their difference is zero. Result = tie.
	*Variation 3:* This is a possible perfect play. Score = 0. Result = tie.
	**Position 0070**, White to move, komi = 0. A cycle occurs in perfect play.
	*Variation 1:* This is a possible perfect play.
	Play 4 creates a cycle. The long-cycle-rule applies. During the cycle 2 black and 2 white stones have been removed from the board. Their difference is zero. Result = tie.

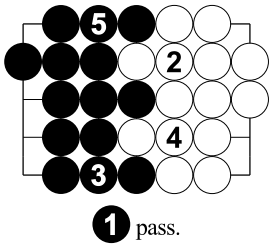
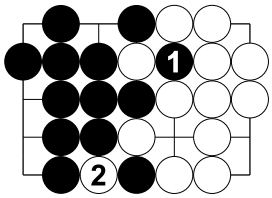
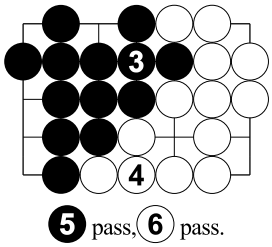
	**Position 0158**, move-sequence in the joseki dictionaries. Players can cooperate to play this long-cycle-tie "joseki". Notes: It is both players' right to play like this. If in a tournament a long-cycle-tie was announced to lead to a replayed game, if the players continue to create long-cycle-ties, but if it is necessary to proceed with the tournament, then eventually the tournament director has these choices: a) keep the tournament rules and declare several winners or b) break the tournament rules and draw lots. Good tournament rules set the choice in advance.
	
	White to move, komi = 7.5.
	Cycle part 1.

	Cycle part 2. Play 43 creates a cycle. The long-cycle-rule applies. During the cycle 3 black and 3 white stones have been removed from the board. Their difference is zero. Result = tie.
	**Position 0050**, Black to move, komi = 0.5. A cycle occurs in perfect play.
	*Variation 1:* This is a possible perfect play.
	Play 8 creates a cycle. The long-cycle-rule applies. During the cycle 4 black and 4 white stones have been removed from the board. Their difference is zero. Result = tie.

Hell-kos

	**Position 0151**, Black to move, komi = 0.5. A cycle does not occur in perfect play.

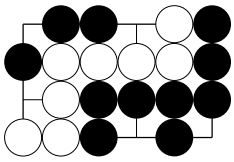
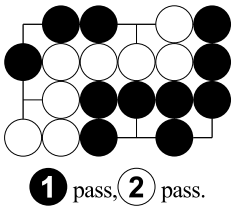
	*Variation 1:* This is a possible perfect play. Score = 0.5. Result = Black win.
	*Variation 2:* This is a possible perfect play.
	Score = 0.5. Result = Black win.
	*Variation 2a:* This is a possible perfect play. Score = 0.5. Result = Black win.
	*Variation 2b:* Move 5 is a strategic mistake. Play 6 creates a cycle. The long-cycle-rule applies. During the cycle 2 black and 2 white stones have been removed from the board. Their difference is zero. Result = tie.

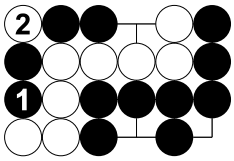
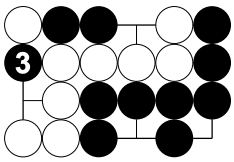
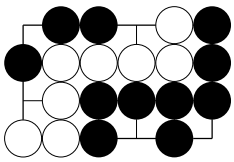
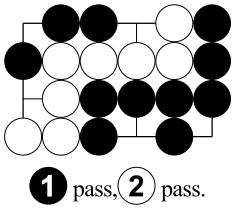
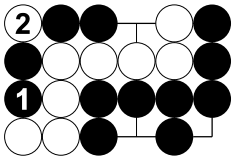
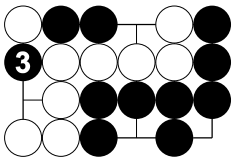
	*Variation 3:* This is a possible perfect play. Score = 0.5. Result = Black win.
	*Variation 4:* This is a possible perfect play. Note: Many other perfect play variations are also possible. This is typical for symmetrical positions.
	Score = 0.5. Result = Black win.

Non-Zero Removals Difference

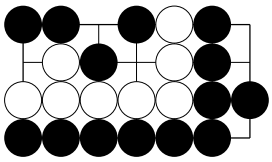
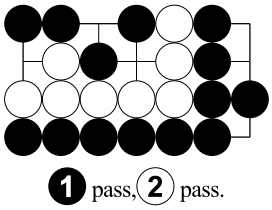
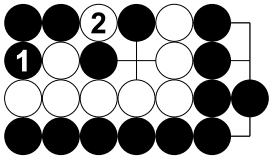
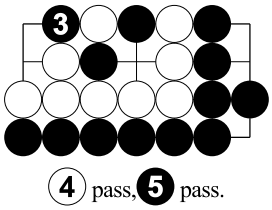
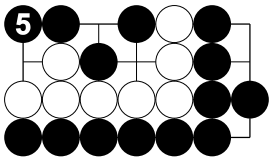
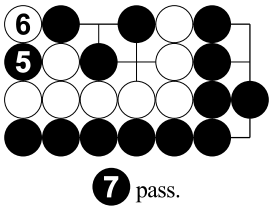
So far only two interesting shape classes with a non-zero removals difference are known.

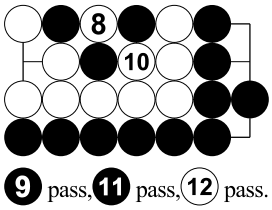
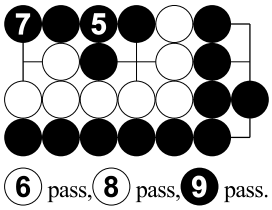
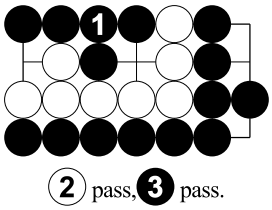
Sending-2-returning-1

	**Position 0134**, Black to move, komi = 0. A cycle does not occur in perfect play.
	*Variation 1:* This is a possible perfect play. Score = 6. Result = Black win.

	*Variation 2:* Move 1 is a strategic mistake.
	Play 3 creates a cycle. The long-cycle-rule applies. During the cycle 2 black and 1 white stones have been removed from the board. Fewer white than black stones have been removed. Result = White win.
	**Position 0134**, Black to move, komi = 7.5. Black can choose how to lose the game: with or without using a cycle.
	*Variation 1:* This is a possible perfect play. Score = -1.5. Result = White win.
	*Variation 2:* This is a possible perfect play.
	Play 3 creates a cycle. The long-cycle-rule applies. During the cycle 2 black and 1 white stones have been removed from the board. Fewer white than black stones have been removed. Result = White win.

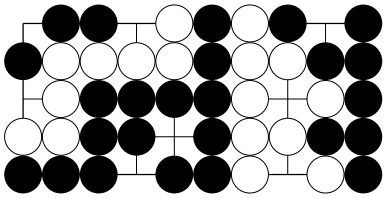
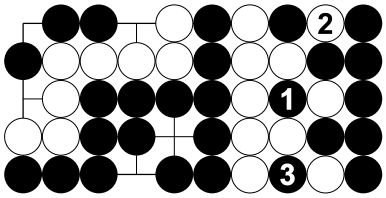
Sending-3-returning-1

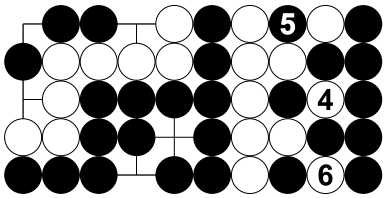
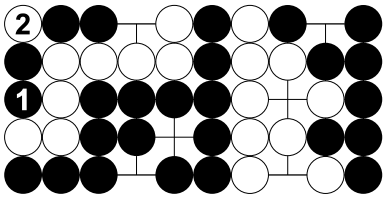
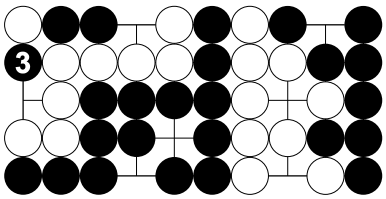
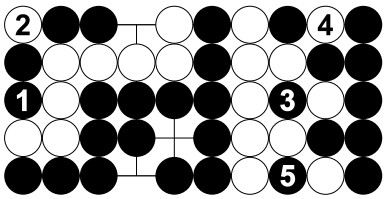
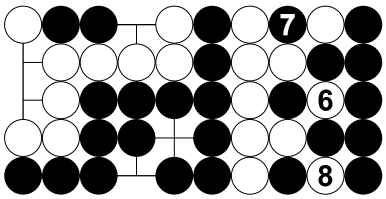
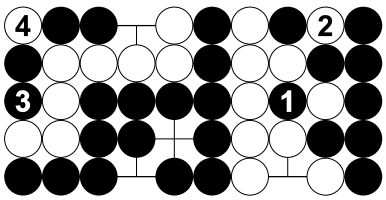
	**Position 0160**, Black to move, komi = 9.5. A cycle does not occur in perfect play.
	*Variation 1:* This is a possible perfect play. Score = 0.5. Result = Black win.
	*Variation 2:* Move 5 is a strategic mistake.
	Score = -0.5. Result = White win.
	*Variation 2a:* Move 5 is a strategic mistake. Play 5 creates a cycle. The long-cycle-rule applies. During the cycle 3 black and 1 white stones have been removed from the board. Fewer white than black stones have been removed. Result = White win.
	*Variation 2b:* Move 5 is a strategic mistake.

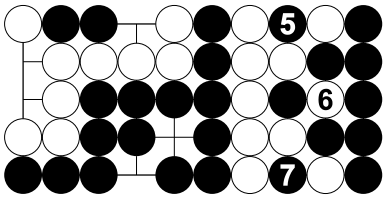
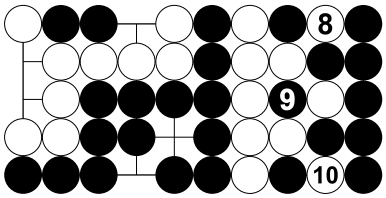
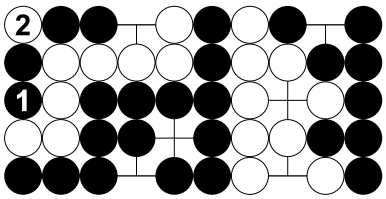
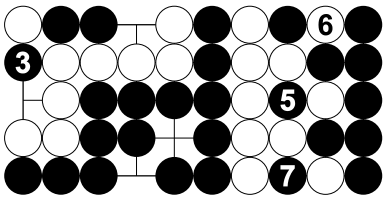
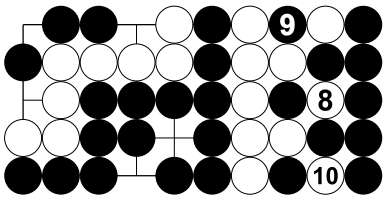
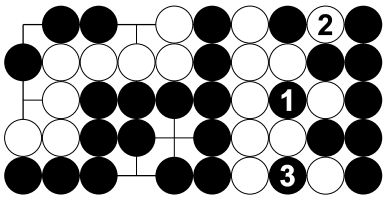
	Score = -11.5. Result = White win.
	*Variation 2c:* This is a possible perfect play. Score = 0.5. Result = Black win.
	*Variation 3:* This is a possible perfect play. Score = 0.5. Result = Black win.

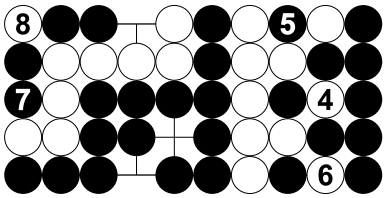
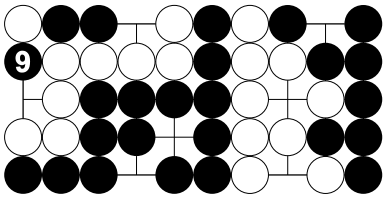
Mixed Positions

A position is "mixed" if it contains both a shape with a zero removals difference and a shape with a non-zero removals difference. The first completed cycle determines the game's result.

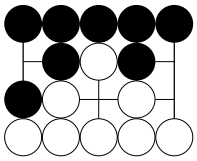
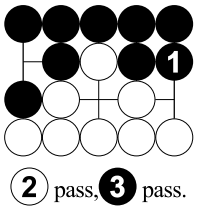
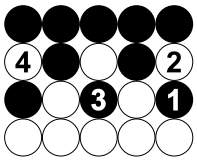
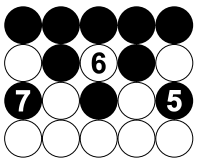
	**Position 0164**, Black to move, komi = 0. It requires strategic skill to play the right cycle.
	*Variation 1:* This is a possible perfect play.

	Play 6 creates a cycle. The long-cycle-rule applies. During the cycle 3 black and 3 white stones have been removed from the board. Their difference is zero. Result = tie.
	*Variation 2:* Move 3 is a strategic mistake.
	Play 3 creates a cycle. The long-cycle-rule applies. During the cycle 2 black and 1 white stones have been removed from the board. Fewer white than black stones have been removed. Result = White win.
	*Variation 3:* This is a possible perfect play. Play 3 is the first of the cycle. Note: It is the players' right to choose difficult strategies.
	Play 8 creates a cycle. The long-cycle-rule applies. During the cycle 3 black and 3 white stones have been removed from the board. Their difference is zero. Result = tie.
	*Variation 4:* This is a possible perfect play.

	Play 5 is the first of the cycle.
	Play 10 creates a cycle. The long-cycle-rule applies. During the cycle 3 black and 3 white stones have been removed from the board. Their difference is zero. Result = tie.
	*Variation 5:* Somewhat late the players call the referee and notice what has happened.
 4 pass.	
	The referee identifies the first completed cycle: the moves 1 to 3. Play 3 created that cycle. The long-cycle-rule applies. During that cycle 2 black and 1 white stones have been removed from the board. Fewer white than black stones have been removed. Result = White win.
	*Variation 6:* Somewhat late the players call the referee and notice what has happened.

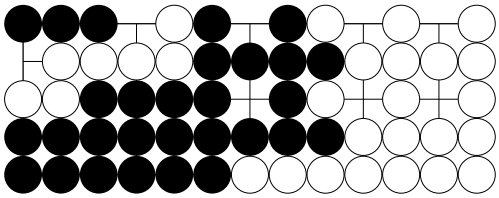
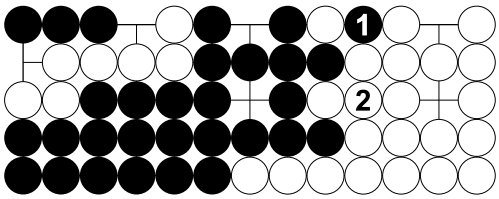
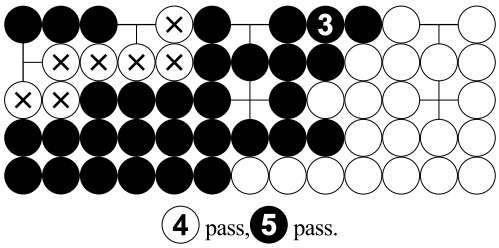
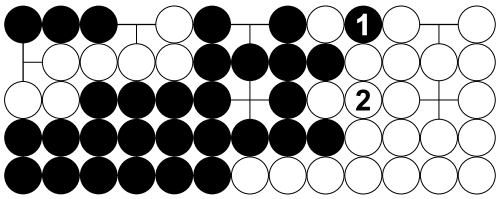
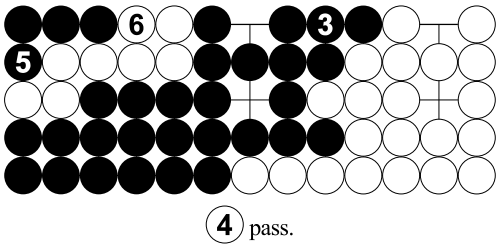
	
	The referee identifies the first completed cycle: the moves 1 to 6. Play 6 created that cycle. The long-cycle-rule applies. During that cycle 3 black and 3 white stones have been removed from the board. Their difference is zero. Result = tie.

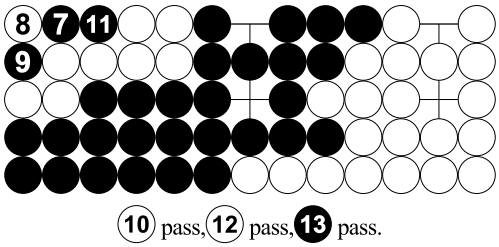
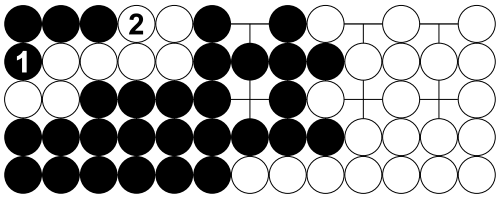
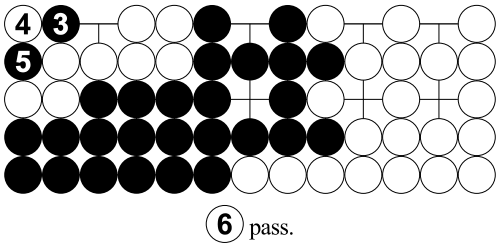
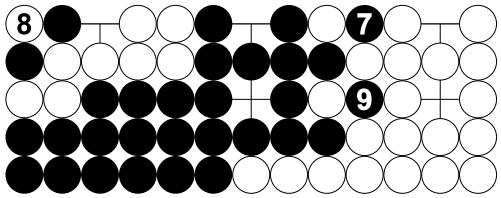
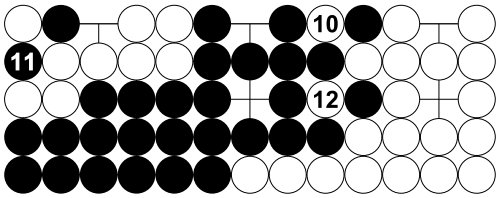
Preliminary Shapes

	**Position 0052**, Black to move, komi = 0. Creating a triple-ko would be a strategic mistake.
	*Variation 1:* This is a possible perfect play. Score = 1. Result = Black win.
	*Variation 2:* Move 1 is a strategic mistake.
	Play 7 creates a cycle. The long-cycle-rule applies. During the cycle 3 black and 3 white stones have been removed from the board. Their difference is zero. Result = tie.

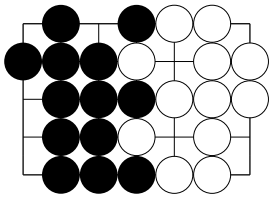
Selected Ko Shapes without Interesting Long Cycles

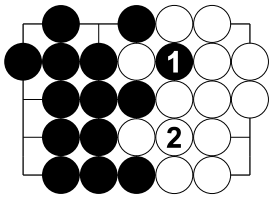
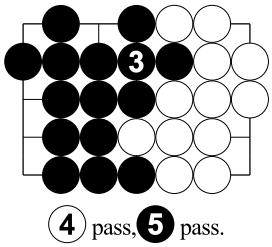
Basic-kos during the Endgame

	Position 0084, Black to move, komi = 0. A cycle does not occur in perfect play.
	*Variation 1:* This is a possible perfect play.
	During the Agreement Phase after move 5, the players agree to remove the marked stones. Score = 19. Result = Black win.
	*Variation 2:* This is a possible perfect play.
	

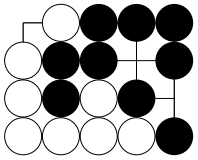
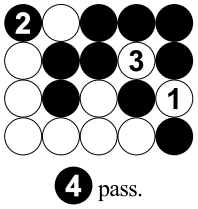
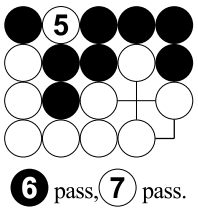
	Score = 19. Result = Black win.
	*Variation 3:* A lot of strategic mistakes are required to create a cycle. Note: Even if the players are strategically very weak, it is still possible to apply the long-cycle-rule.
	
	Play 12 creates a cycle: it recreates the position just after play 5. The long-cycle-rule applies. During the cycle 3 black and 3 white stones have been removed from the board. Their difference is zero. Result = tie.

Hell-kos

	**Position 0155**, Black to move. A cycle does not occur in perfect play.

	*Variation 1:* This is a possible perfect play.
	Score = 5. Result = Black win.

Pendulum-ko

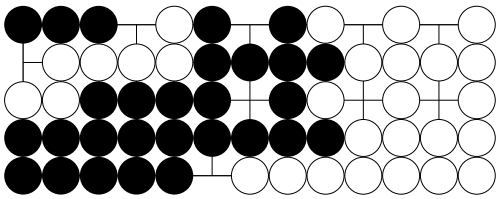
	**Position 0057**, White to move. A cycle does not occur in perfect play. Note: During the middle game, there can be a ko fight similar to that of a basic-ko.
	*Variation 1:* This is a possible perfect play.
	Score = -20. Result = White win.

Wasting One's Time: Removals Difference Zero

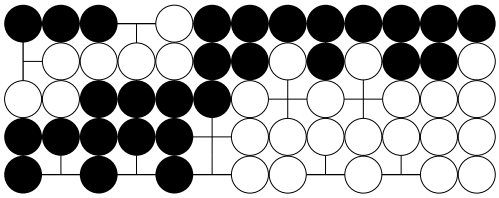
It is possible to study arbitrarily many shapes, spend arbitrarily much time on such study, and forget that one should be studying rules rather than shapes. The following shapes are not

studied so as not to waste time. They just remind the reader that one can waste time if one wants to.

Basic-kos during the Endgame

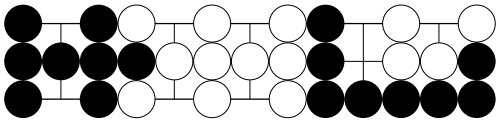


0085



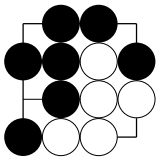
0086

Basic-kos and Other Ko(s)

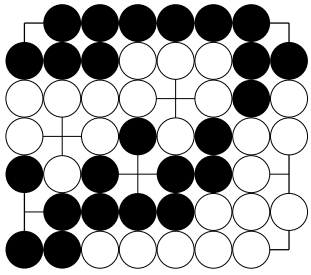


0107

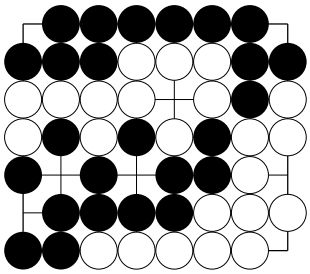
Double-ko-seki



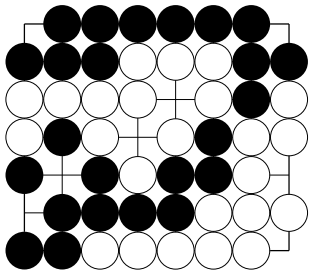
0074



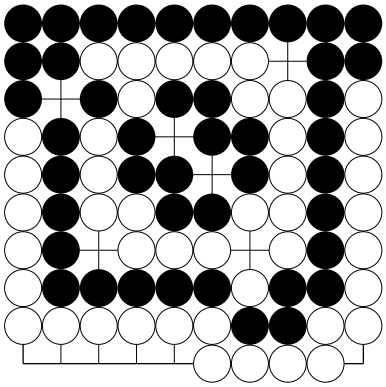
0087



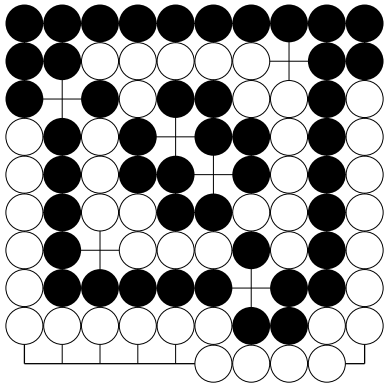
0088



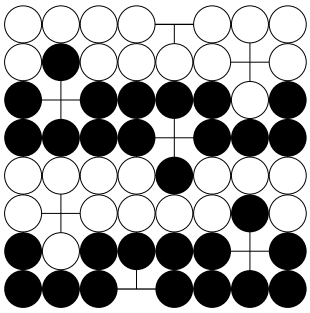
0089



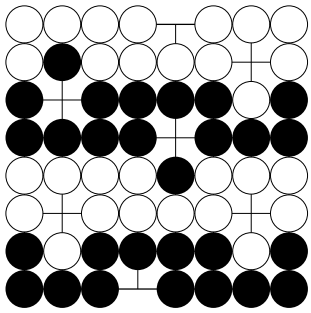
0185



0186

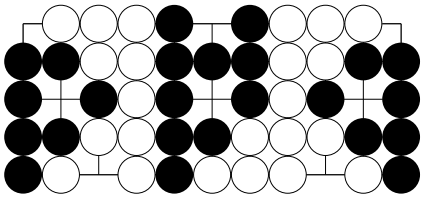


0187

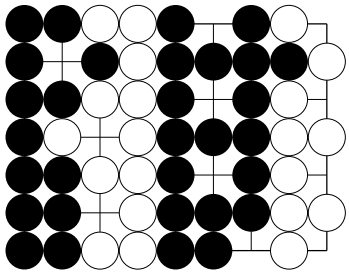


0188

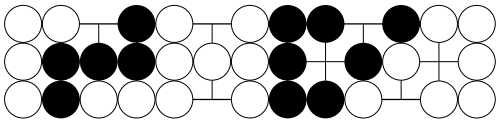
Double-ko-seki and Other Ko(s)



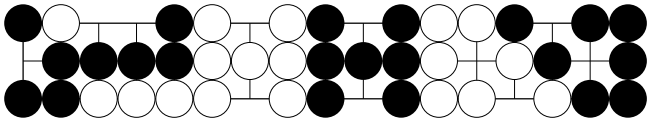
0092



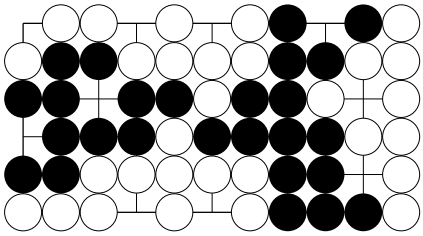
0108



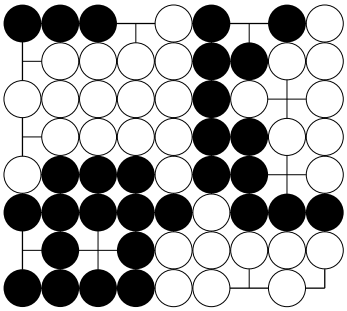
0093



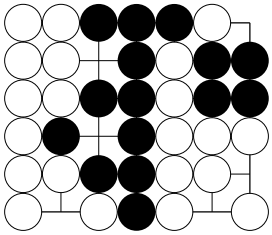
0094



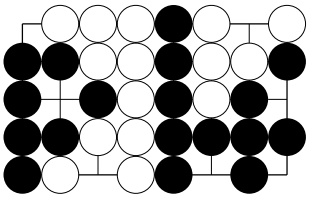
0147



0148

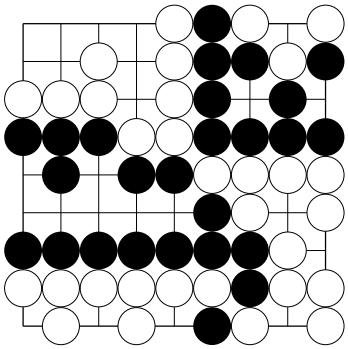


0150

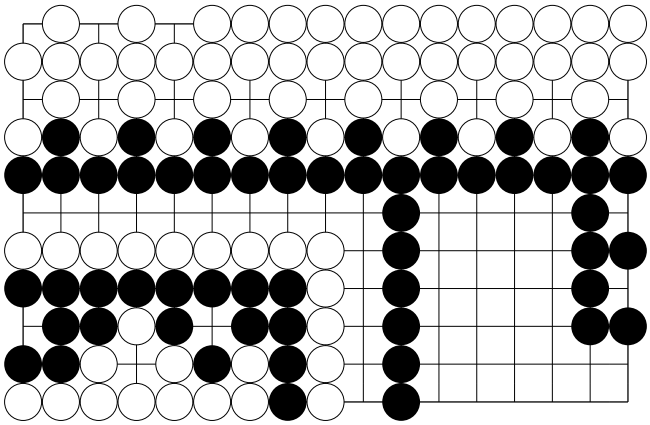


0063

Double-ko-death and Other Kos



0157



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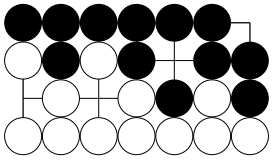
Triple-ko



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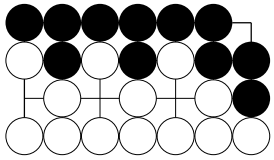

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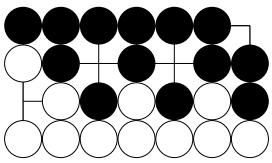

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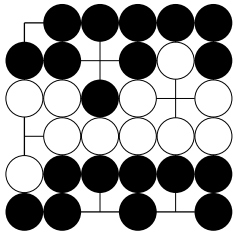

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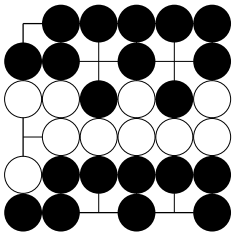

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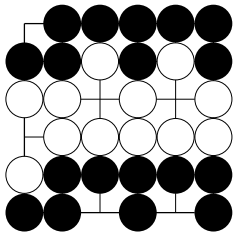

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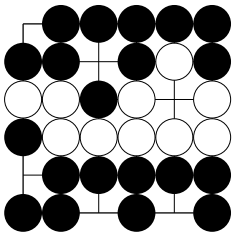
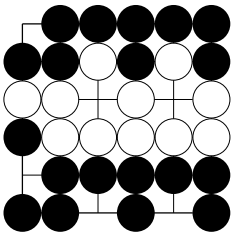
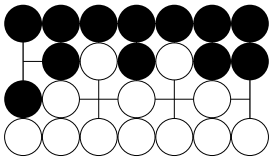
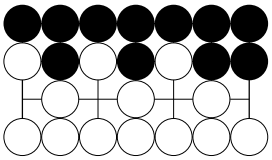
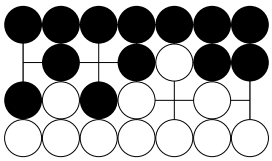
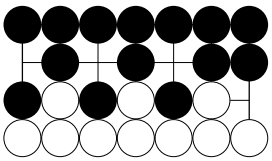
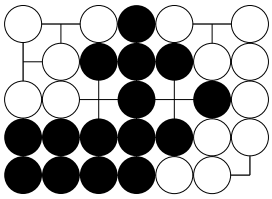
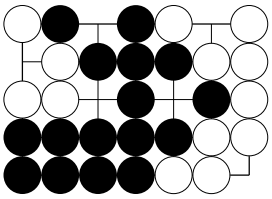
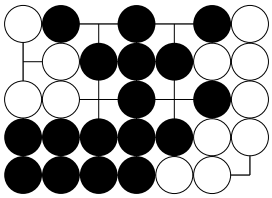
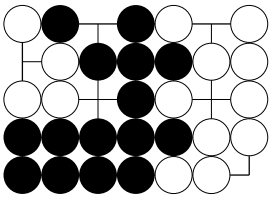
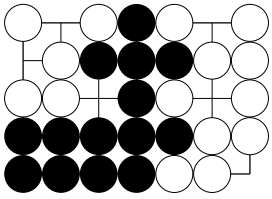
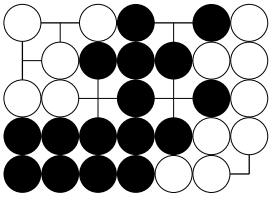
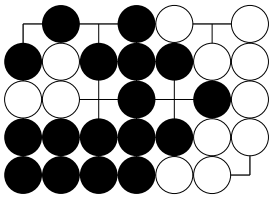
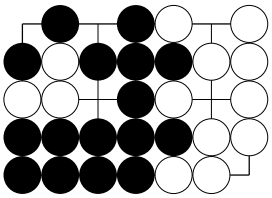
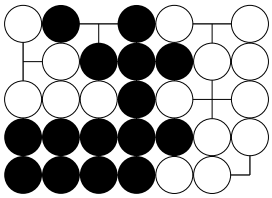
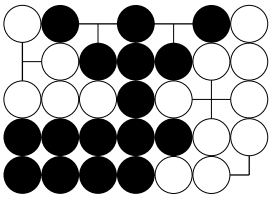
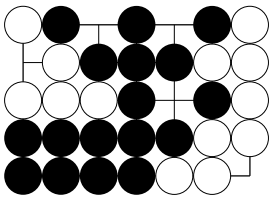
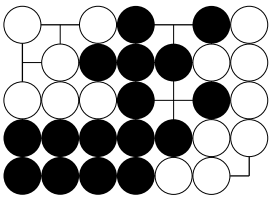
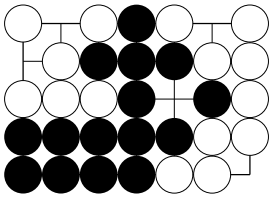
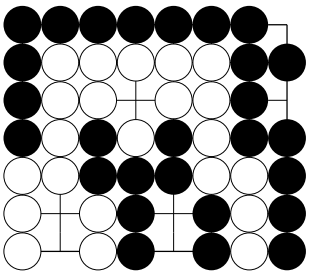
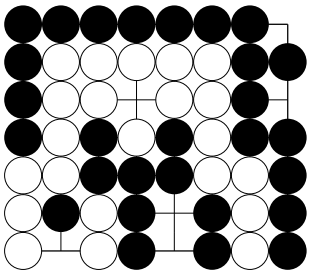
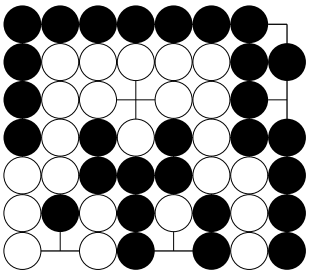
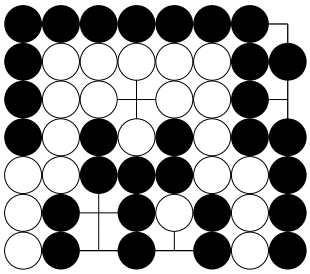
 0101	 0102
 0103	 0104
 0105	 0106

Shapes Similar to Triple-ko

 0121	 0122
 0123	 0124
 0125	 0126

 0127	 0128
 0129	 0130
 0131	 0132
 0133	 0165
 0166	 0167



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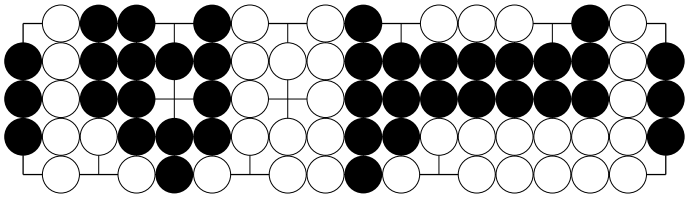

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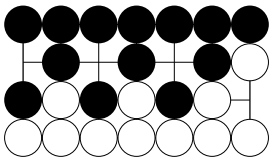
n-tuple-kos



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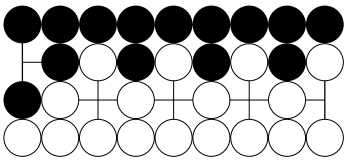

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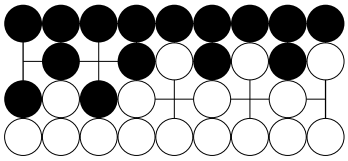

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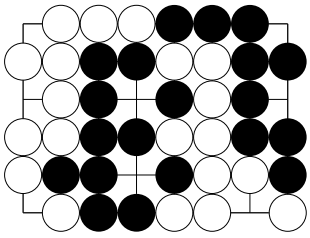
Variants of n-tuple-kos



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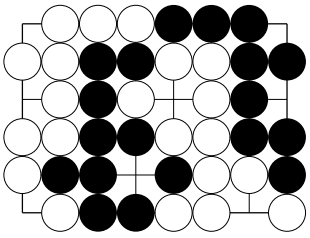

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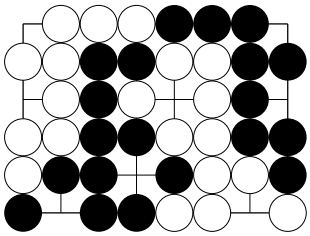

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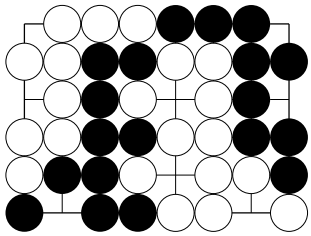

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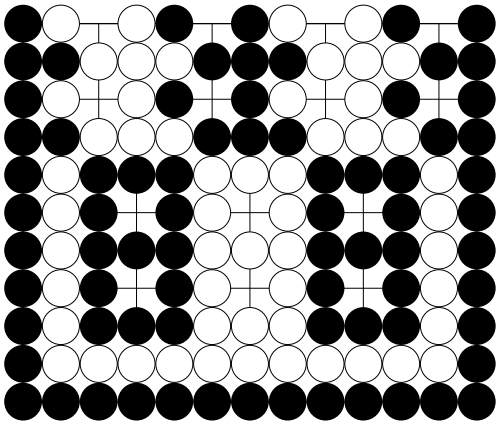

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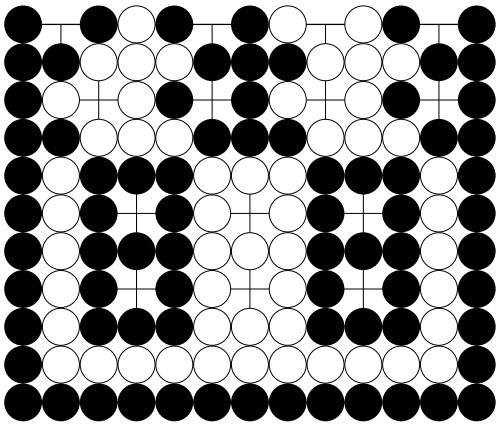

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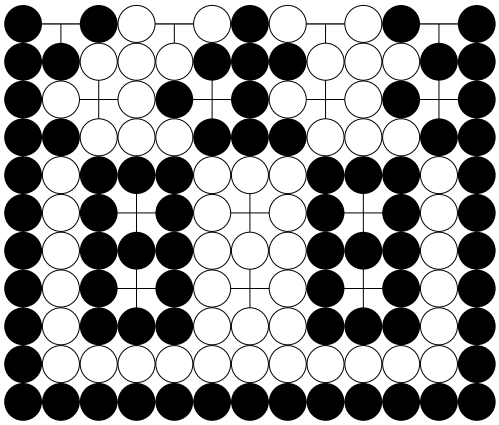

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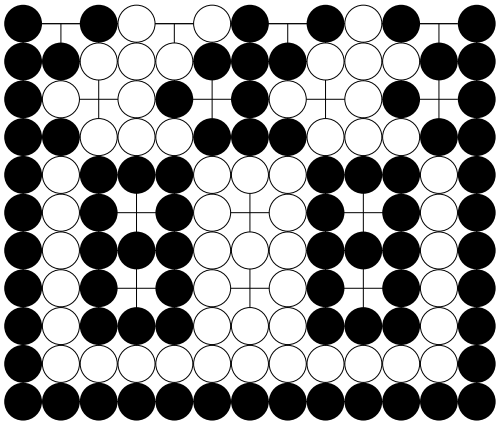

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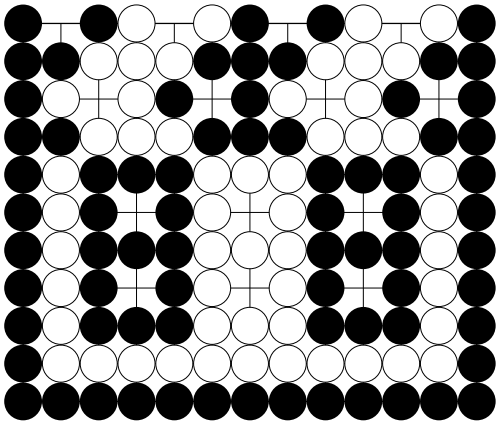

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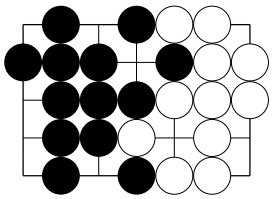
Hell-kos



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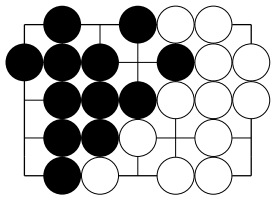

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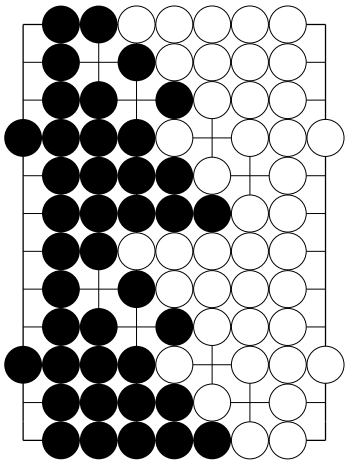
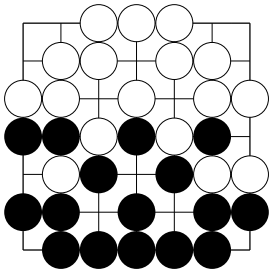


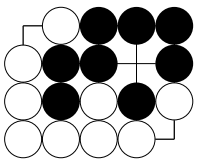
0154

Other Big Ko Spaces



0189

Pendulum-ko



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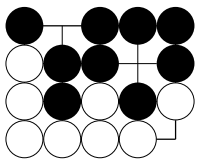

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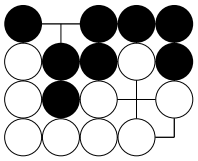
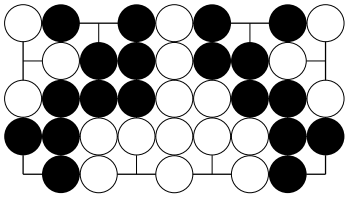
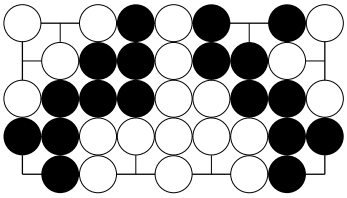
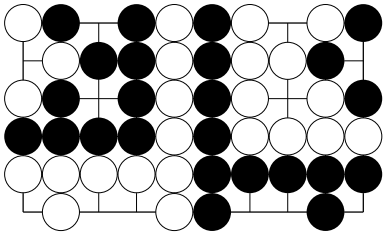
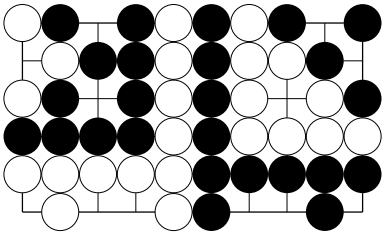
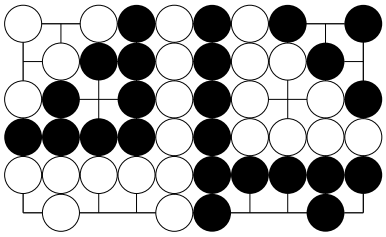
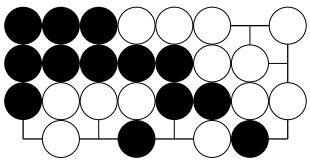
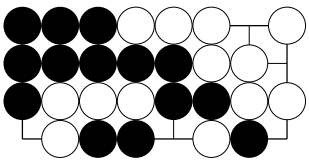
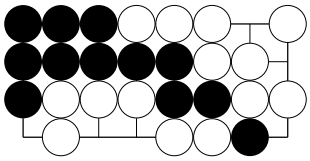
 0078	

Multiple Disturbing-deaths

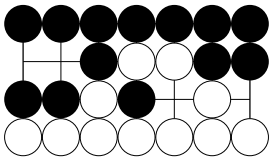
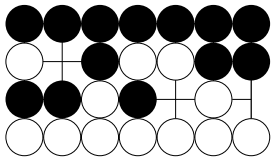
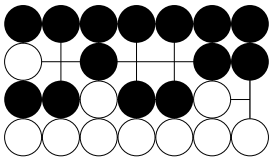
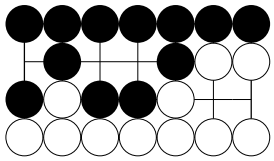
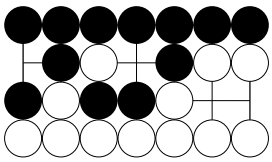
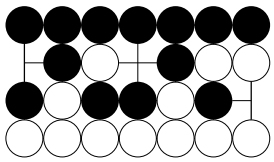
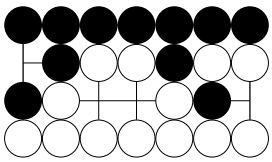
 0048	 0064
 0059	 0079
 0080	

Eternal-life

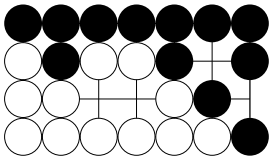
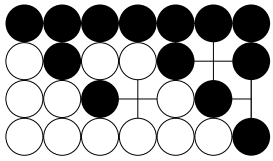
 0051	 0068

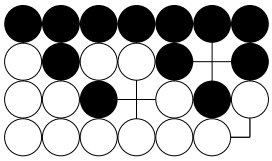
 0069	

Round-robin-ko

 0065	 0066
 0067	 0117
 0118	 0119
 0120	

Molasses-ko

 0053	 0071



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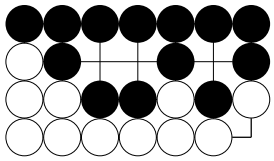
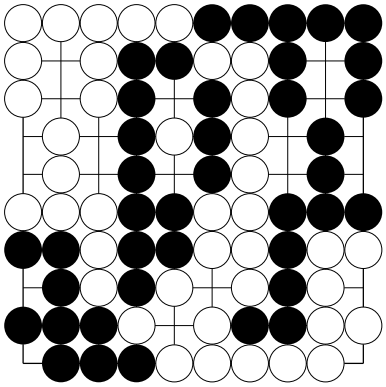


0073

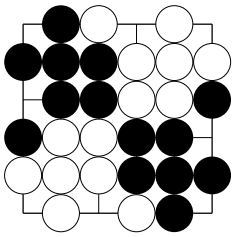
Multiple Ko Stones

An interesting position with quadruple ko stones has also been discovered but is not shown here.



0149

Ring-around-a-rose



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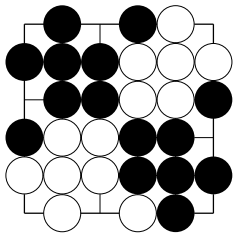
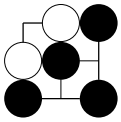
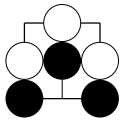


0114

Windmill-ko



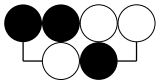
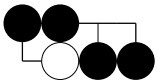
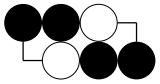
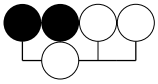
0115



0116

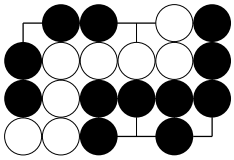
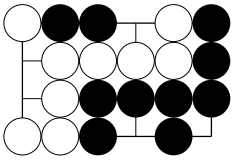
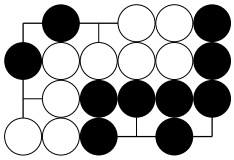
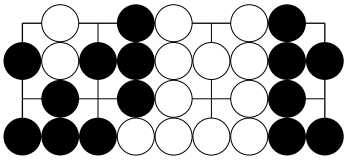
Diamond-ko

This shape is impossible on the 19x19 board.

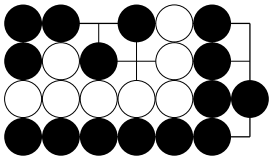
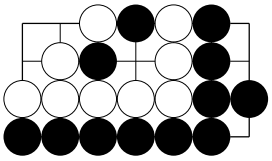
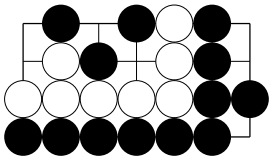
 0139	 0140
 0141	 0142

Wasting One's Time: Non-Zero Removals Difference

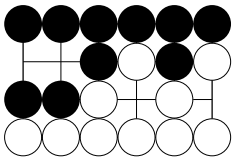
Sending-2-returning-1

 0135	 0136
 0137	 0138

Sending-3-returning-1

 0161	 0162
 0163	

Wasting One's Time: Selected Ko Shapes without Interesting Long Cycles



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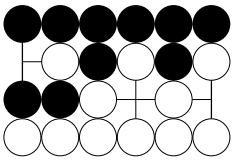

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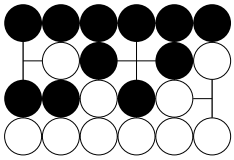

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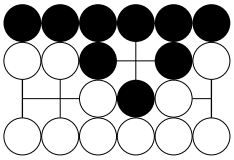

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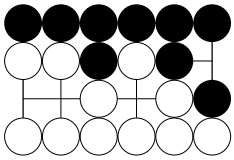
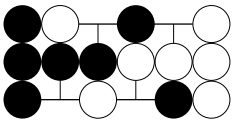


0173



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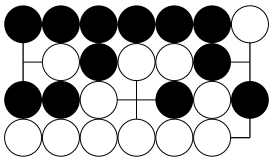

0175