Magic games can produce some pretty high numbers. There are lots of ways to go infinite and reach numbers as high as you want, but you don't have to go infinite to get enormous results.

But how many cards does it take to pull that off? For this challenge, we'll take a look at five damage targets, each time aiming to find the minimum cards needed to hit the target, and to pick ones that will get as high as possible.

The rules:

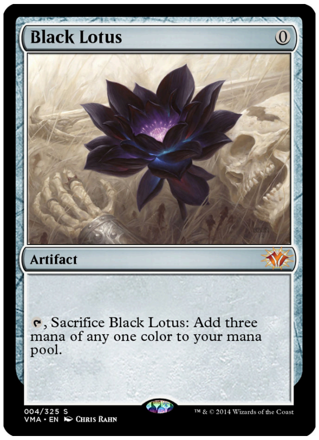
- Start with an otherwise Vintage-legal deck of as few cards as we need to hit the target. If it's less than 7, we don't lose from our starting hand forcing us to draw from an empty library. After starting hands, all normal rules apply.
- The game only lasts one turn. Any sort of extra turn effects will not change that. (Presumably, we'll want to go first, so the turn is ours rather than the opponent's.)
- Randomness can play out however we want. This includes starting hands, cards drawn, die rolls, etc. The results can be as unlikely as we want, as long as they're possible.
- The opponent has a deck of the same size, consisting of nothing but Wastes. (And with the same starting-hand rules.) They'll never concede the game, but if they're offered any other choice, they'll act in whatever way will minimize our score.
- Both players start with 20 life, and all normal game-ending conditions apply. If we hit the opponent hard enough that they lose the game, we can't keep hitting them afterward, so if we want to get them far into negative life, we'll probably need to do it all at once.
- Decks are scored based on how much they can reduce the opponent's life total in the allotted time, as long as there's an upper bound. If, for any integer N, the deck could reduce the opponent's life by that much or more, the deck is disqualified and gets a score of 0. Otherwise, the score is 20 minus X, where X is the opponent's final life total after we've played the deck in accordance with the previous rules. Only the final life total matters, not how we get there.

If you're interested in more background on the decks here, they're all from the MTG Salvation limited-card challenge thread here. In addition, many of the strategies here are based on techniques developed in the main Turn 1 maximum finite damage thread.

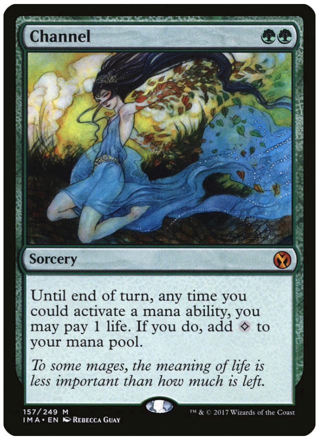
With all that in mind, let's begin!

Challenge #1: Win the Game

Our first goal: Deal at least 20 damage to win the game on the first turn. Simple enough.

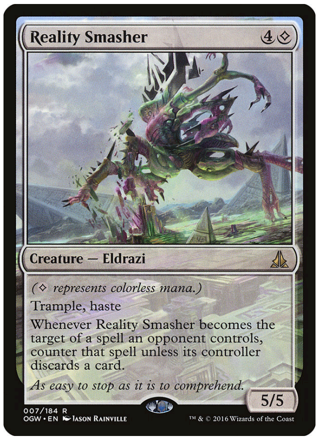


, Sacrifice Black Lotus: Add three mana of any one color to your mana pool.



Until end of turn, any time you could activate a mana ability, you may pay 1 life. If you do, add ◇ to your mana pool.

To some mages, the meaning of life is less important than how much is left.

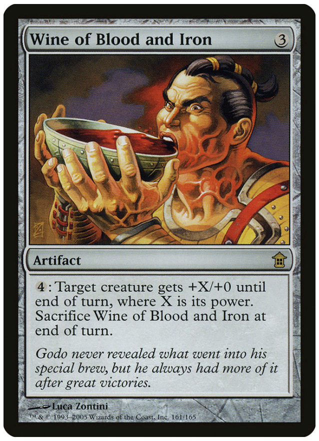


(◇ represents colorless mana.)

Trample, haste

Whenever Reality Smasher becomes the target of a spell an opponent controls, counter that spell unless its controller discards a card.

As easy to stop as it is to comprehend.



4: Target creature gets +X/+0 until end of turn, where X is its power. Sacrifice Wine of Blood and Iron at end of turn.

Godo never revealed what went into his special brew, but he always had more of it after great victories.

1. Black Lotus
2. Channel
3. Reality Smasher
4. Wine of Blood and Iron

To start, we'll play Black Lotus, sacrifice it for three green mana, and use two of that to play Channel. A powerful opener, and one we'll see again.

Using Channel, pay all 19 life we can spare, bringing our total mana to 20. Spend 5 to play Reality Smasher, and 3 to play Wine of Blood and Iron. That leaves 12 mana, enough to activate Wine of Blood and Iron three times.

The first activation doubles Reality Smasher's power from 5 to 10. The second makes it 20, the third makes it 40. Go to combat, swing for 40 damage.

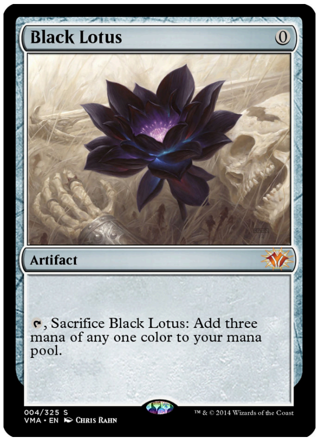
Cards: 4
Score: 40

A quick, clean win. But these numbers are ones you might see in a relatively normal game. With more cards, we can do much more.

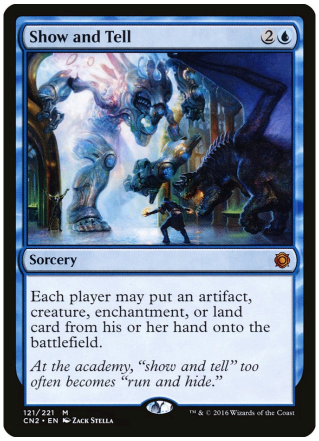
Say, speaking of doubling…

Challenge #2: A Million Damage

A much loftier goal, but one we can manage with just a single additional card. To ease into things, we'll look at two versions, both with five cards but different choices for the last one.



Black Lotus
0
Artifact
, Sacrifice Black Lotus: Add three mana of any one color to your mana pool.
004/325 S
VMA • EN Chris Rahn
™ & © 2014 Wizards of the Coast



Show and Tell
2
Sorcery
Each player may put an artifact, creature, enchantment, or land card from his or her hand onto the battlefield.
At the academy, "show and tell" too often becomes "run and hide."
121/221 M
CN2 • EN Zack Stella
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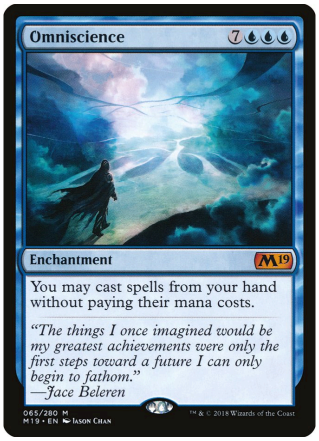
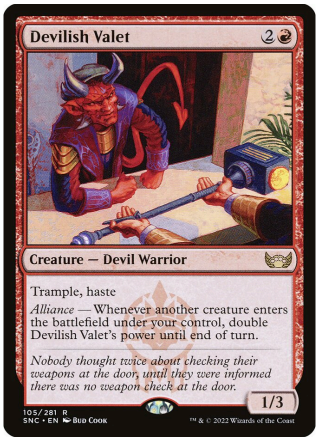
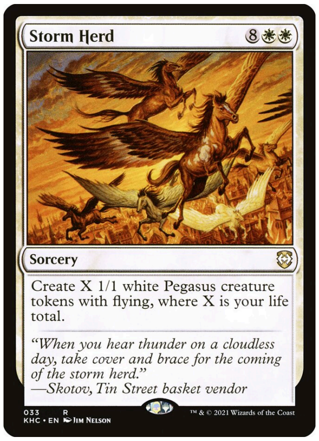


Omniscience
7
Enchantment
M19
You may cast spells from your hand without paying their mana costs.
"The things I once imagined would be my greatest achievements were only the first steps toward a future I can only begin to fathom."
—Jace Beleren
065/280 M
M19 • EN Jason Chan
™ & © 2018 Wizards of the Coast



Devilish Valet
2
Creature — Devil Warrior
Trample, haste
Alliance — Whenever another creature enters the battlefield under your control, double Devilish Valet's power until end of turn.
Nobody thought twice about checking their weapons at the door, until they were informed there was no weapon check at the door.
1/3
105/281 R
SNC • EN Bud Cook
™ & © 2022 Wizards of the Coast



Storm Herd
8
Sorcery
Create X 1/1 white Pegasus creature tokens with flying, where X is your life total.
"When you hear thunder on a cloudless day, take cover and brace for the coming of the storm herd."
—Skotov, Tin Street basket vendor
033 R
KHC • EN Jim Nelson
™ & © 2021 Wizards of the Coast

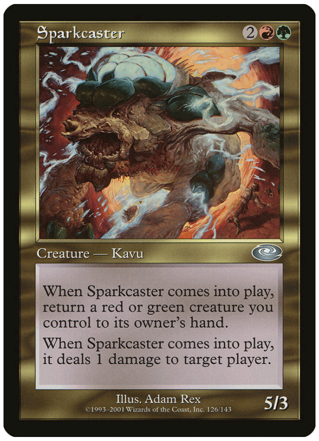
1. Black Lotus
2. Show and Tell
3. Omniscience
4. Devilish Valet
5. Storm Herd

Once again, open with Black Lotus, but this time sacrifice it for blue mana to play Show and Tell. Which in turn lets us play Omniscience, making our remaining cards free.

Next, play Devilish Valet, followed by our final card.

For the Storm Herd version, we get 20 Pegasus tokens. Each one causes Davilish Valet's power to double, from 1 to 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048, 4096, 8192, 16384, 32768, 65536, 131072, 262144, 524288, and finally 1,048,576.

There's our million damage. But using a different final card lets us do even better.



When Sparkcaster comes into play, return a red or green creature you control to its owner's hand.

When Sparkcaster comes into play, it deals 1 damage to target player.

5. Sparkcaster

Sparkcaster can return itself to our hand, letting us keep playing it to double Devilish Valet's power even more times. Many similar cards would go infinite, but Sparkcaster's second ability provides a constraint.

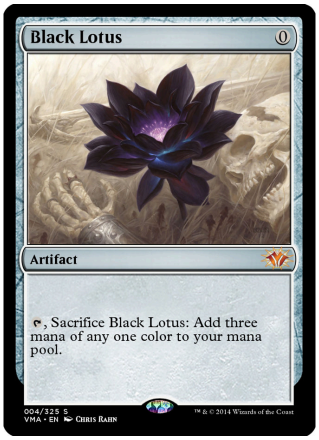
Every time we play it, it deals 1 damage to a player - either the opponent or ourselves. Each player starts with with 20 life, so we can play it 38 times without ending the game, dealing 19 damage to each player in the process. That raises Valet's power to 2^38 - over 274 billion - and gives us a total score of 2^38 + 19.

Cards: 5
Score: 274,877,906,963

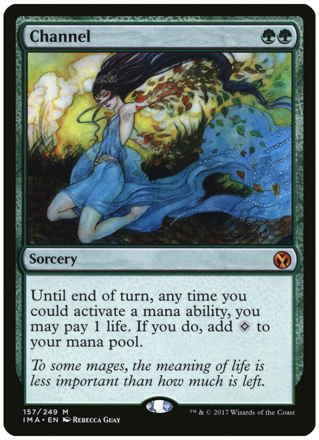
That's the last time we'll be able to write out our final damage in full.

Challenge #3: Googolplex

Time for the real shenanigans to start.

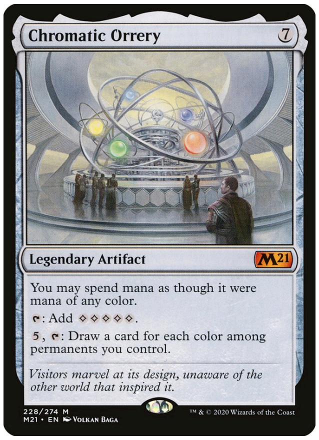


↷, Sacrifice Black Lotus: Add three mana of any one color to your mana pool.



Until end of turn, any time you could activate a mana ability, you may pay 1 life. If you do, add ◇ to your mana pool.

To some mages, the meaning of life is less important than how much is left.

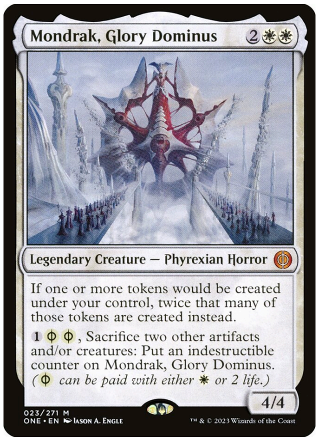


You may spend mana as though it were mana of any color.

↷: Add ◇◇◇◇◇.

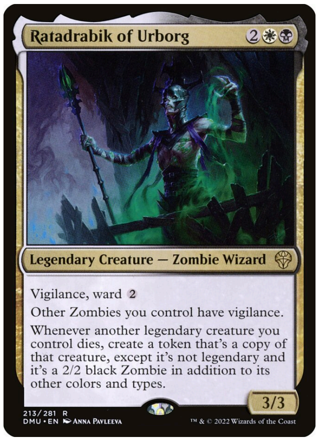
5, ↷: Draw a card for each color among permanents you control.

Visitors marvel at its design, unaware of the other world that inspired it.


Mondrak, Glory Dominus
2
Legendary Creature — Phyrexian Horror
4/4
023/271 M
ONE • EN Jason A. Engle
™ & © 2023 Wizards of the Coast

If one or more tokens would be created under your control, twice that many of those tokens are created instead.

1 Φ Φ, Sacrifice two other artifacts and/or creatures: Put an indestructible counter on Mondrak, Glory Dominus. *(Φ can be paid with either ☀ or 2 life.)*


Ratadrabik of Urborg
2
Legendary Creature — Zombie Wizard
3/3
213/281 R
DMU • EN Anna Pavleeva
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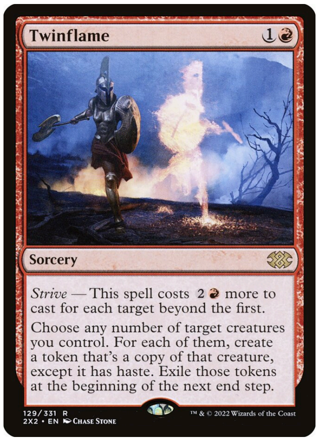
Vigilance, ward 2

Other Zombies you control have vigilance.

Whenever another legendary creature you control dies, create a token that's a copy of that creature, except it's not legendary and it's a 2/2 black Zombie in addition to its other colors and types.



Strive — This spell costs 2 more to cast for each target beyond the first.

Choose any number of target creatures you control. For each of them, create a token that's a copy of that creature, except it has haste. Exile those tokens at the beginning of the next end step.

1. Black Lotus
2. Channel
3. Chromatic Orrery
4. Mondrak, Glory Dominus
5. Ratadrabik of Urborg
6. Twinflame

Like in the first challenge, we'll open with Black Lotus and Channel, then spend 19 life to put us at 20 mana. This time, we have some more complicated costs involved, so we'll follow that by spending 7 mana to play Chromatic Orrery, which lets us spend the rest of our mana on whatever we want. It also taps for 5 mana, putting us at 18.

Spend 8 mana to play Mondrak and Ratadrabik. Then spend 5 mana to play Twinflame, targeting both of them.

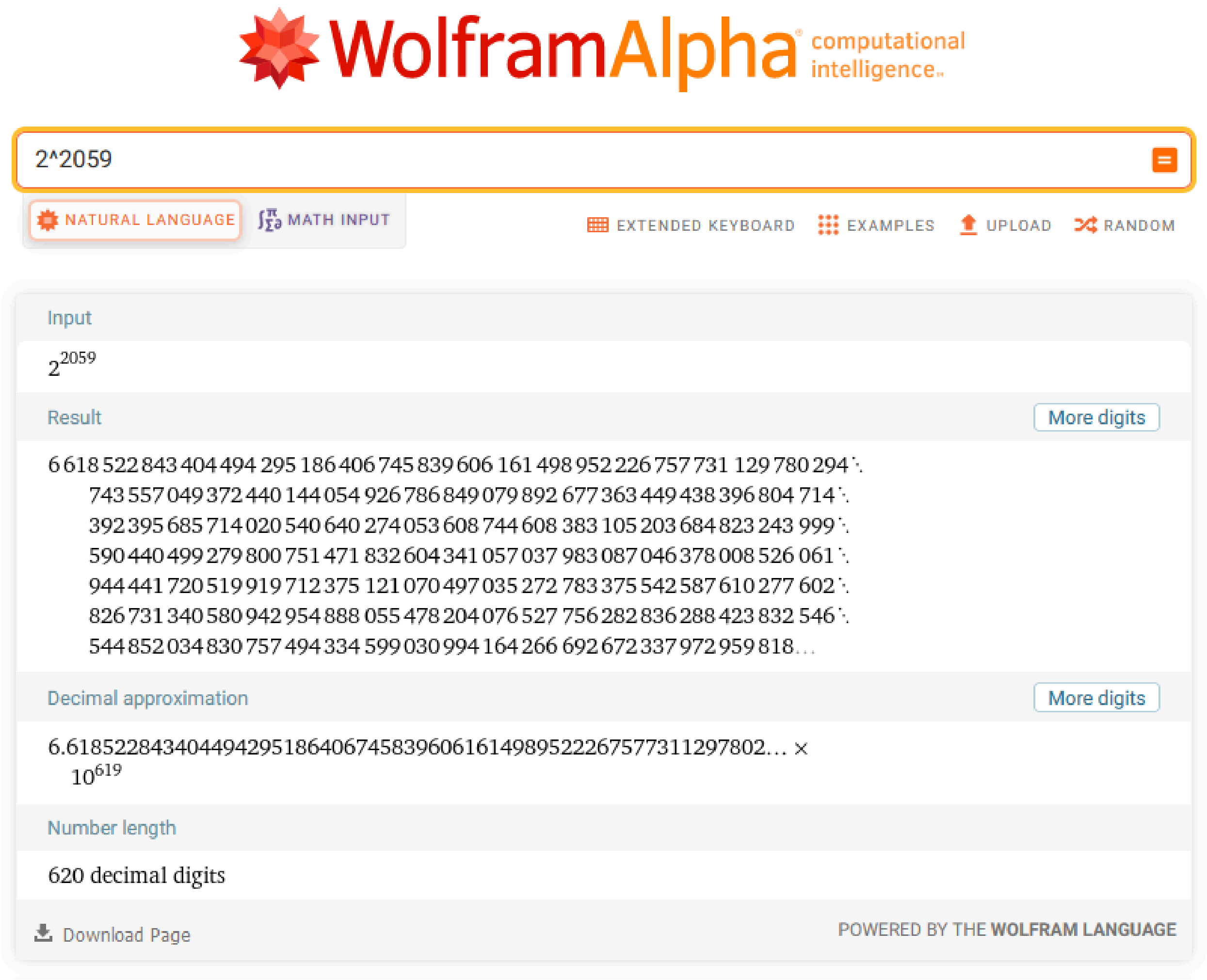
Twinflame would normally create one token copy of each, but Mondrak doubles that to two, so we end up with three of each of our legends. The legend rule kicks in, and we immediately have to give up two of them. For each one, we'll choose the originals since they don't have haste, plus one of the tokens.

All of these deaths happen simultaneously, so all three Ratadrabiks see them happen. Ratadrabik doesn't trigger on its own death, so the two Ratadrabik deaths only cause two Ratadrabik triggers each for a total of four, but the Mondrak deaths cause three, for a total of six.

Each Ratadrabik trigger creates a copy of the creature that died, doubled for each Mondrak we have. The resulting tokens aren't legendary, so they won't die to the legend rule anymore, but that also means we can't get more Ratadrabik triggers out of them. The tokens *do* retain haste if the legendary creature that died was a Twinflame token, since Twinflame includes haste in its initial definition of the tokens.

We'll let the six Ratadrabik>Mondrak triggers resolve first, starting with the ones from the original Mondrak that didn't have haste.

1. 2^1 is 2. Create two Mondrak tokens, for a total of three.
2. 2^3 is 8. Create eight Mondrak tokens, for a total of eleven.
3. 2^11 is 2048. Create 2048 Mondrak tokens, for a total of 2059.
4. 2^2059 is…



2^2059

Input

2^{2059}

Result

```
6 618 522 843 404 494 295 186 406 745 839 606 161 498 952 226 757 731 129 780 294 ⋱
    743 557 049 372 440 144 054 926 786 849 079 892 677 363 449 438 396 804 714 ⋱
    392 395 685 714 020 540 640 274 053 608 744 608 383 105 203 684 823 243 999 ⋱
    590 440 499 279 800 751 471 832 604 341 057 037 983 087 046 378 008 526 061 ⋱
    944 441 720 519 919 712 375 121 070 497 035 272 783 375 542 587 610 277 602 ⋱
    826 731 340 580 942 954 888 055 478 204 076 527 756 282 836 288 423 832 546 ⋱
    544 852 034 830 757 494 334 599 030 994 164 266 692 672 337 972 959 818…
```

Decimal approximation

$6.6185228434044942951864067458396061614989522267577311297802\ldots \times 10^{619}$

Number length

620 decimal digits

Okay, this is getting unsustainable. We've jumped to a number higher than googol, and we're not slowing down from here. Let's shift our perspective.

The fourth trigger creates 2^2059 tokens. Technically, this gives us a total of 2059+2^2059, but we can round that down to just 2^2059 because the difference is so far from being significant at this point.

The fifth trigger creates 2^2^2059 tokens. Incidentally, we can also approximate this as 2^(6.61 x 10^619), which is a bit more than 10^10^619. Googolplex is 10^10^100, so we've already passed our goal!

But we're still not finished. The sixth and final Ratadrabik>Mondrak trigger resolves, giving us 2^2^2^2059 tokens.

This is getting to be a lot of 2s. Multiplication is repeated addition, exponentiation is repeated multiplication, and we're doing repeated exponentiation, but there's a word for that: Tetration.

In tetration, we can write 2^^N to represent 2^2^2^...2, where N is the number of 2s present. 2^2 is 4, 2^2^2 is 16, and 2^2^2^2 is 65536, so we'll round 2059 down to 16 and call our result 2^2^2^2^2^2, or 2^^6. That's a pretty big underestimate of our actual number of tokens, but we're working with numbers so big that more precision isn't very practical.

With over 2^^6 Mondraks, our token production is doubled 2^^6 times, and doubling something 2^^6 times is the same as multiplying it by 2^^7. So when we resolve the four Ratadrabik>Ratadrabik triggers, each one gives us 2^^7 Ratadrabiks, for a total of… still 2^^7. Regular multiplication is too small for us to notice it anymore.

We could attack with 2^^7 hasted Ratadrabiks, and get our greater-than-googolplex damage. But there's one more thing we can do.

In addition to all the nonlegendary tokens created from the Ratadrabik triggers, we still have two legendary tokens, the ones that survived the legend rule earlier. We also have 5 mana left, which is more than enough. Spend 3 of it to activate one of our Mondraks, sacrificing those two tokens.

Sacrificing a legendary Mondrak gives us 2^^7 Ratadrabik triggers, and sacrificing a legendary Ratadrabik does the same thing. In addition, since these were tokens created from Twinflame, they have haste, and therefore the resulting copies will also have haste.

6 Ratadrabik>Mondrak triggers got us to 2^^6 Mondraks. 2^^7 Ratadrabik>Mondrak triggers gets us to 2^^2^^7 Mondraks. Then we can resolve the Ratadrabik>Ratadrabik triggers, for over 2^^2^^7 hasted Ratadrabiks.

Go to combat, swing with everything that has haste. 2^^6 is bigger than googolplex, 2^^7 is bigger still, and 2^^2^^7 is far bigger than either of those, so we've gone well past our target.

Cards: 6
Score: 2^^2^^7

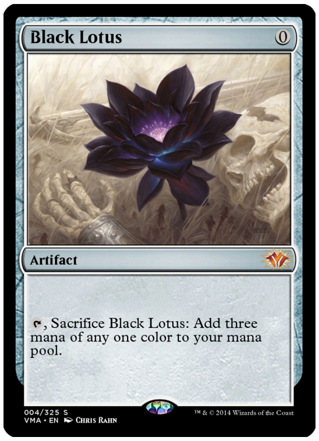
Let's keep going.

Challenge #4: Graham's Number

Tetration is an extremely powerful operation, but even higher-order operations are possible. Repeated tetration is called pentation, and uses a third arrow (2^^^N).

With additional layers of recursion, you can add even more arrows. The well-known 2015 megacombo used 60 cards to reach 407 arrows worth of damage on the first turn, by stacking up a huge chain of operations that each allow for many repetitions of every operation before them.

But current strategies can do even better.


Black Lotus
0
Artifact
, Sacrifice Black Lotus: Add three mana of any one color to your mana pool.
004/325 S
VMA • EN Chris Rahn
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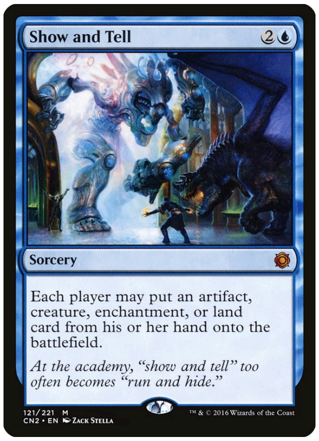
Show and Tell
2
Sorcery
Each player may put an artifact, creature, enchantment, or land card from his or her hand onto the battlefield.
At the academy, "show and tell" too often becomes "run and hide."
121/221 M
CN2 • EN Zack Stella
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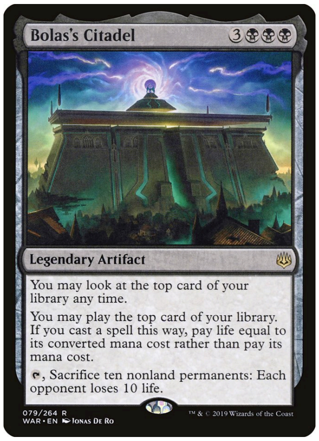
Bolas's Citadel
3
Legendary Artifact
You may look at the top card of your library any time.
You may play the top card of your library. If you cast a spell this way, pay life equal to its converted mana cost rather than pay its mana cost.
, Sacrifice ten nonland permanents: Each opponent loses 10 life.
079/264 R
WAR • EN Jonas De Ro
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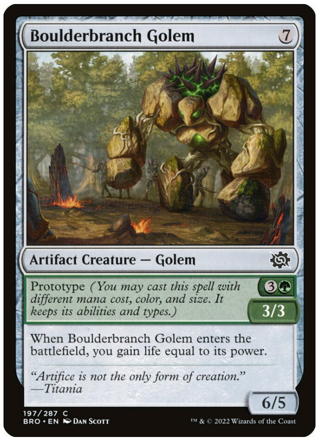
Boulderbranch Golem
7
Artifact Creature — Golem
Prototype (You may cast this spell with different mana cost, color, and size. It keeps its abilities and types.)
3
3/3
When Boulderbranch Golem enters the battlefield, you gain life equal to its power.
"Artifice is not the only form of creation."
—Titania
6/5
197/287 C
BRO • EN Dan Scott
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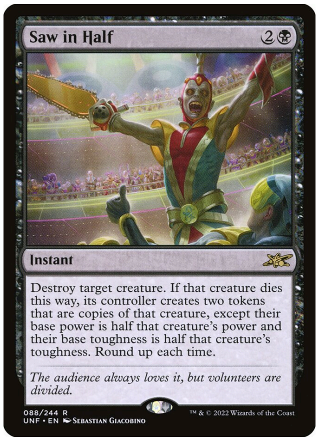
Saw in Half
2
Instant
Destroy target creature. If that creature dies this way, its controller creates two tokens that are copies of that creature, except their base power is half that creature's power and their base toughness is half that creature's toughness. Round up each time.
The audience always loves it, but volunteers are divided.
088/244 R
UNF • EN Sebastian Giacobino
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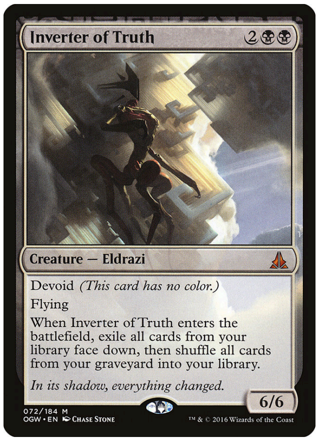
Inverter of Truth
2
Creature — Eldrazi
Devoid (This card has no color.)
Flying
When Inverter of Truth enters the battlefield, exile all cards from your library face down, then shuffle all cards from your graveyard into your library.
In its shadow, everything changed.
6/6
072/184 M
OGW • EN Chase Stone
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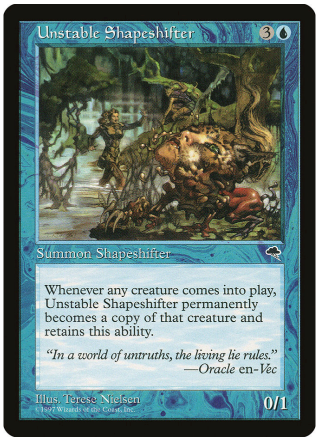
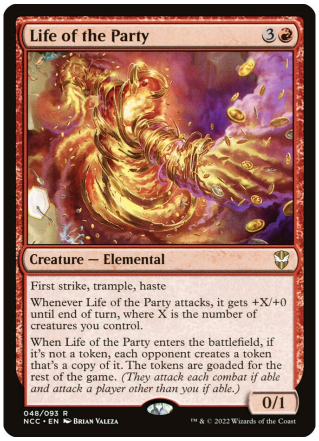

Unstable Shapeshifter
3
Summon Shapeshifter
Whenever any creature comes into play, Unstable Shapeshifter permanently becomes a copy of that creature and retains this ability.
"In a world of untruths, the living lie rules."
—Oracle en-Vec
Illus. Terese Nielsen
© 1997 Wizards of the Coast, Inc.
0/1


Life of the Party
3
Creature — Elemental
First strike, trample, haste
Whenever Life of the Party attacks, it gets +X/+0 until end of turn, where X is the number of creatures you control.
When Life of the Party enters the battlefield, if it's not a token, each opponent creates a token that's a copy of it. The tokens are goaded for the rest of the game. (They attack each combat if able and attack a player other than you if able.)
0/1
048/093 R
NCC • EN Brian Valeza
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1. Black Lotus
2. Show and Tell
3. Bolas's Citadel
4. Boulderbranch Golem

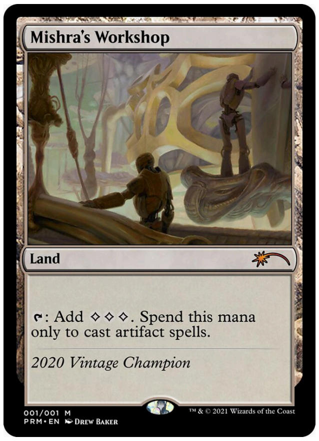
5. Saw in Half
6. Inverter of Truth
7. Unstable Shapeshifter
8. Life of the Party

This deck is even stranger. What's going on here?

This time we'll start by taking two mulligans, to start with 5 cards in hand and 3 in our library. For this deck, cards in the library are often easier to access.

Play Black Lotus, sacrifice it for blue mana, and play Show and Tell, using it to bring out Bolas's Citadel. Then spend 7 life to play Boulderbranch Golem from the top of our library, unprototyped, so it shows up with 6 power and gives us back 6 life, putting us at 19.

(We could get an equivalent start by replacing Show and Tell with Mishra's Workshop, using it alongside Black Lotus to cast Bolas's Citadel directly. This would be safer against an opponent with an unknown deck, but would also mean adding a second high-end Reserved List card.)


Mishra's Workshop

Land

↷: Add ◇◇◇. Spend this mana only to cast artifact spells.

2020 Vintage Champion

Spend 3 life to play Saw in Half from the library, turning the 6/5 Golem into two 3/3 tokens. Each one gives us 3 life, so we go to 22.

Spend another 4 life (now 18) to play Inverter of Truth from the library. This exiles our now-empty library, and returns Black Lotus, Show and Tell, Saw in Half, and the original Boulderbranch Golem from our graveyard to our new library.

Replay Black Lotus for free, then replay Boulderbranch Golem (18-7+6=17). Replay Saw in Half (14 life), now targeting Inverter of Truth, to make two Inverters and get two Inverter triggers. Resolving the first trigger exiles Show and Tell from the library and puts back Saw and Inverter.

Before the second trigger resolves, sacrifice Black Lotus for three blue mana, and replay Saw from library to split the nontoken Boulderbranch into two 3/3 Golems (14-3+6=17). The second trigger exiles the original Inverter and shuffles back Black Lotus, Saw, and Boulderbranch.

We'll go through this same process a second time. Replay Lotus and Boulderbranch (16 life), play Saw on an Inverter (13 life), use one Inverter trigger to play Saw on Boulderbranch (16 life), then sacrifice Lotus for another three mana and use the second Inverter trigger to reshuffle everything. We've traded 1 life for 3 mana.

With 6 mana now, we can play Unstable Shapeshifter from hand. Replay Lotus and Boulderbranch from the library (15 life), causing Unstable Shapeshifter to become a copy of the 6/5 Golem, while keeping its copy ability.

Play Saw>Inverter again (12 life), getting two Inverter triggers, as well as two triggers of Unstable Shapeshifter trying to copy the smaller Inverters. Have the two Inverter triggers resolve first. The first puts back Saw, letting us replay it (9 life) on the Shapeshifter that is currently a 6/5 golem, turning it into two 3/3 Shapeshifter-Golems (15 life). The second puts back Black Lotus, Saw, and Unstable Shapeshifter, in that order, preparing us to start another loop. (Then the Shapeshifter triggers resolve, trying to turn the original Shapeshifter into an Inverter, but nothing happens since that Shapeshifter is gone by now.)

From here, replay Black Lotus one last time, then do another pair of Saw casts: once on an Inverter, once on the original Boulderbranch. As always, we get back the 6 life we spent and move Saw back to our library for each time we've played it, so the net effect is just to move Boulderbranch back from the battlefield to the library. We've also gotten a few more tokens, and because we left the original Unstable Shapeshifter card in our library, it's exiled now.

Let's review the current situation:

- On the battlefield, we have Black Lotus, Bolas's Citadel, two Unstable Shapeshifter tokens each copying a 3/3 Boulderbranch Golem, eight regular 3/3 Boulderbranch Golem tokens, and five Inverter of Truth tokens. (Sizes of the Inverter tokens may vary depending on the choice of targets, and it's not going to matter anyway. They won't be attacking.)
- Boulderbranch Golem and Saw in Half are in our library, while we've exiled Show and Tell and the original cards for Inverter of Truth and Unstable Shapeshifter. Our graveyard is empty.
- We have one card left in hand, and two mana in our mana pool.
- We're at 15 life, which is our main resource right now. Moving Boulderbranch Golem from our library to the battlefield requires spending 7 life and gives back 6 life, for a net cost of 1 life, but once we hit 7 life, we won't be able to start the process anymore.
- Playing Saw twice, on an Inverter and a 6/5 Golem, gives back all the life it costs and ends up with Saw back in the library. We can do this freely to move the original Boulderbranch back to our library when necessary, or to turn a 6/5 Shapeshifter-Golem into two smaller Shapeshifter-Golems.
- Playing the original Boulderbranch from our library (at a cost of 1 life) gives each of our current Shapeshifters triggers to become 6/5 Shapeshifter-Golems, which we can in turn

target with Saw to increase our Shapeshifter count (without any further net decrease in life). By stacking the triggers properly, we have each of them resolve only when we're ready to play Saw on the resulting Shapeshifter-Golem in question, so we don't miss the chance by having it turn into something else.
- While we're working our way through a batch of 6/5 Shapeshifter-Golem triggers, any new Shapeshifters created won't have such a trigger, so we can let those become Inverters and then target those with Saw when we need to target an Inverter. This further increases our total Shapeshifter count, which is our primary output.

Now we can start doing this properly.

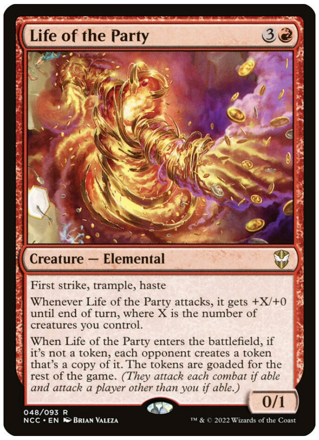
Play Boulderbranch from library (14 life), giving copy triggers to both Shapeshifters. When the first resolves, turning it into a 6/5 Shapeshifter-Golem, use Saw to split it into two Shapeshifter-Golems. Do the same thing with the second one, in the process allowing the previous two Shapeshifters to become Inverters. This results in two Shapeshifter-Inverters and two 3/3 Shapeshifter-Golems, for a total of four Shapeshifters.

To repeat the loop, play Saw on a Shapeshifter-Inverter (5 Shapeshifters) and the original Boulderbranch, then replay Boulderbranch (13 life) for another round of 6/5 copy triggers - now five of them. We don't want to destroy any of the Shapeshifters waiting for one of those, so we'll start by using a regular Inverter to split the first one (6 Shapeshifters). From there, in order to start turning new Shapeshifters into Inverters, we'll need to use a regular Inverter to split the second one as well (7 Shapeshifters). After that, we can start using the Saw pairs on both a Shapeshifter-Inverter and a 6/5 Shapeshifter-Golem, so the remaining three each increase our Shapeshifter count by two (13 Shapeshifters).

This loop cost 1 life and brought our Shapeshifter count from 4 to 13. More generally, each time we do this, it will take us from N Shapeshifters to 3N+1. Therefore:

- Going to 12 life puts us at 40 Shapeshifters.
- Going to 11 life puts us at 121 Shapeshifters.
- Going to 10 life puts us at 364 Shapeshifters.
- Going to 9 life puts us at 1093 Shapeshifters.
- Going to 8 life puts us at 3280 Shapeshifters.
- Going to 7 life puts us at 9841 Shapeshifters.

This has been a lot of work to reach an unusually normal number, but we do have one last card in hand.


Life of the Party
3
Creature — Elemental
First strike, trample, haste
Whenever Life of the Party attacks, it gets +X/+0 until end of turn, where X is the number of creatures you control.
When Life of the Party enters the battlefield, if it's not a token, each opponent creates a token that's a copy of it. The tokens are goaded for the rest of the game. *(They attack each combat if able and attack a player other than you if able.)*
0/1
048/093 R
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Sacrifice Black Lotus for three red mana. Combined with our mana from earlier, we have enough to play Life of the Party. This turns all 9841 Shapeshifters into copies of it. (It also gives the opponent a Life of the Party token.)

Go to combat, attack wth all 9842 of them. They all get triggers to increase their power based on the number of creatures we control, and we'll set the original's trigger to resolve last.

Before any of the triggers resolve, play Saw on an Inverter, and this time allow the Shapeshifters to become Inverters, then use the second Saw play on the original Boulderbranch Golem so all the Shapeshifters become 3/3 Shapeshifter-Golems. But they still have attack triggers on the stack, and now, we'll allow the first one to resolve.

At this point, we have 9841 Shapeshifter-Golems, 1 Life of the Party, 24 non-Shapeshifter Golem tokens, and 22 Inverters. So the first attack trigger increases its Shapeshifter-Golem's power by 9888, making its stats 9891/3.

Saw in Half defines the tokens it creates based on the current stats of the creature it targets. So playing Saw on a 9891/3 Shapeshifter-Golem creates a pair of 4946/2 Shapeshifter-Golems, causing us to gain 9892 life, and creating triggers to turn *all* of our Shapeshifters into 4946/2 Shapeshifter-Golems. Another Saw can turn one of those 4946/2 Shapeshifters into a pair of 2473/1s - but this is where we have to be careful, since we want to keep the other one at 4946 for now, so we'll always put its copy triggers on the bottom of the stack and make sure to avoid letting them resolve until we've made proper use of that 4946 Shapeshifter as well.

In the meantime, we continue the process. 2473 becomes 1237, then 619, 310, 155, 78, 39, 20, 10, 5, and finally 3. In the meantime, we keep stacking the triggers to delay the ones that would turn larger Shapeshifter-Golems into smaller ones. Like before, 3-power Golems are the smallest we can make while still rebouping the 6 life spent on the double Saw round - but this time, we've accumulated a whole lot of additional life. Specifically, we've gained (4946+2473+1237+619+310+155+78+39+20+10+5+3)*2=19790 life, while spending 6*12=72 life between the 12 Saw pairs, and we went in with 7 life so we end up at 19725 life.

A Saw round on a smaller Shapeshifter-Golem costs a net of 2-4 life, but we can now afford to do that several thousand times. We can also start allowing the new, smaller Shapeshifters to become Shapeshifter-Inverters again, further increasing the Shapeshifter production rate. Once we've spent as much life as we can afford this way, we'll continue.

Playing Saw on a 10/1 Shapeshifter-Golem turns *all* of our new Shapeshifters into 5/1s. That's big enough to gain the needed 3 life when split, so this lets us repeat the strategy from earlier to triple our number of small Shapeshifters.

Playing Saw on a 20/1 Shapeshifter turns all the new ones into 10/1s. With N small Shapeshifters, this lets us triple our number of small Shapeshifters N times, getting us to 3^N. We're doing exponentiation, now.

Playing Saw on a 39/1 Shapeshifter turns the new ones into 20/1s, letting us exponentiate N times. Now we're at 3^^N, for tetration.

Each higher power tier lets us reuse all our new Shapeshifters at the tier below it, adding another layer of recursion and putting us at a higher-order operation. Therefore:

- 78 power reaches 3^^^N
- 155 power reaches 3^^^^N
- 310 power reaches 3^^^^^N
- 619 power reaches 3^^^^^^N
- 1237 power reaches 3^^^^^^^N
- 2473 power reaches 3^^^^^^^^N
- 4946 power reaches 3^^^^^^^^^N

We only made two 4946/1 Shapeshifter-Golems and we had to use one of them to get started, so the other provides us a single iteration of this chain. We can never use smaller Shapeshifters to make larger ones, which keeps the chain finite, even as the number of smaller Shapeshifters produced by each larger one grows more and more unfathomable. To get full use out of the larger Shapeshifters, we'll always wait to use them until we work our way through all the smaller ones, and avoid letting them resolve any more copy triggers before we've used them.

To assess the total number of Shapeshifters created in the 9-arrow round from the 4946-power Shapeshifter, we can start with 3^^^^^^^^^2 (equivalent to the 8-arrow 3^^^^^^^^3) and increment a single time, to 3^^^^^^^^^3. That constitutes the lower bound for the number of Shapeshifters we've created. Like in the previous strategy, we have to round down to keep things manageable.

That's the first attack trigger. Resolving the second one gives the next attacking Shapeshifter 3^^^^^^^^^3 power.

Once again, we get a layer of recursion for each time we can halve the attacker's power before reaching small numbers, a function of the power's base-2 logarithm. But this time, that power - and therefore the number of layers and arrows - is enormous. Logarithms, like multiplication and division, aren't even noticeable at this point: we've already rounded down by far larger amounts.

The 2015 megacombo reached 407 arrows. The second attack trigger gets us to 3^^^^^^^^^^3 arrows, dwarfing that by an unfathomable scale. And the number represented by all those arrows will become the number of arrows we get from the third trigger.

Ultimately, each round gives an output roughly following the Ackermann Function, where the input number determines the number of arrows in the output. We can express the second trigger's output as F{w}(3^^^^^^^^^^3), which means the third trigger's output is in turn F{w}(F{w}(3^^^^^^^^^^3)).

Once again, this will become unsustainable, as we have a lot of triggers to work through. But we can write N successive applications of F{w}, starting with F{w}(N), as F{w+1}(N).

This operation - repeatedly taking an input N, and outputting a result with N arrows - is the premise of Graham's Number:

$$G = \left.\begin{matrix} 3\uparrow\uparrow\cdots\cdots\cdots\cdots\cdots\uparrow 3 \\ \underbrace{\qquad\qquad\qquad\qquad\qquad} \\ 3\uparrow\uparrow\cdots\cdots\cdots\cdots\uparrow 3 \\ \underbrace{\qquad\qquad\qquad\qquad} \\ \vdots \\ \underbrace{\qquad\qquad\qquad} \\ 3\uparrow\uparrow\cdots\cdots\uparrow 3 \\ \underbrace{\qquad\qquad} \\ 3\uparrow\uparrow\uparrow\uparrow 3 \end{matrix}\right\}\text{64 layers}$$

The first number in Graham's sequence, g1, is 3^^^^3. That's between the input and output of the first attack trigger, so we can round our first output down to g1. By the same token, we can do lowball estimates of our second output as g2, our third as g3, etc. After 64 attack triggers, we'll pass Graham's Number, g64.

We started this process by attacking with 9841 Shapeshifters, plus the original Life of the Party. The final attack trigger, from the original, will translate our final number of creatures into damage. The opponent can block with their own token, but it's a 0/1, and Life of the Party has trample.

As a result, the attacking Shapeshifters allow us to repeat this process 9841 times. The first trigger falls short of F{w}(9841), but afterward we can surpass it, giving us a final damage of over F{w+1}(9840).

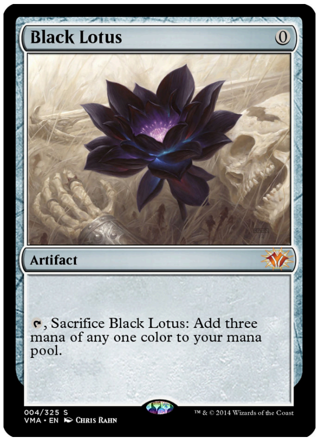
Cards: 8
Score: F{w+1}(9840)

One more challenge left.

Challenge #5: Turing Complete

Ackermann combos are powerful, and while Saw in Half is the easiest way to set one up, it's not the only one. We can build on them by adding more layers of recursion on top, or even chaining consecutive Ackermann stages together.

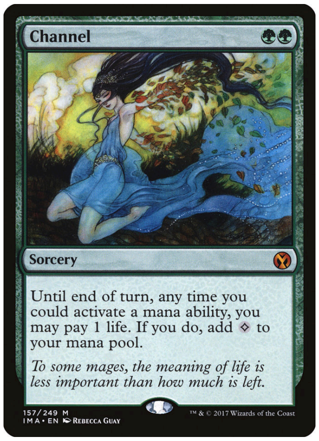
But there's an even stronger option available. By building a sufficiently large Turing machine, we can run programs that increase their output more dramatically than even Ackermann stages.



Black Lotus 0

Artifact

↷, Sacrifice Black Lotus: Add three mana of any one color to your mana pool.

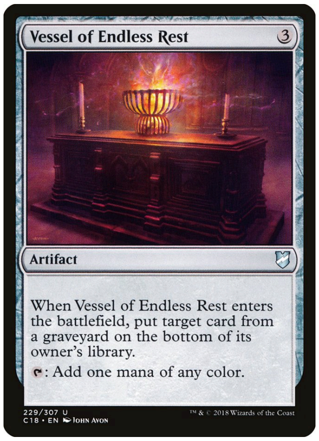


Channel

Sorcery

Until end of turn, any time you could activate a mana ability, you may pay 1 life. If you do, add ◇ to your mana pool.

To some mages, the meaning of life is less important than how much is left.

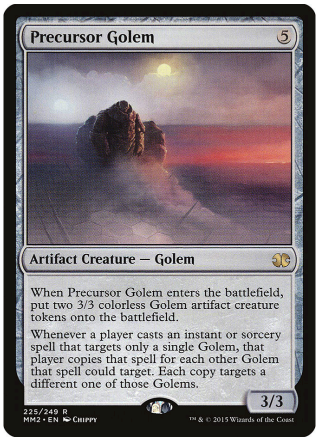


Vessel of Endless Rest 3

Artifact

When Vessel of Endless Rest enters the battlefield, put target card from a graveyard on the bottom of its owner's library.

↷: Add one mana of any color.



Precursor Golem 5

Artifact Creature — Golem

When Precursor Golem enters the battlefield, put two 3/3 colorless Golem artifact creature tokens onto the battlefield.

Whenever a player casts an instant or sorcery spell that targets only a single Golem, that player copies that spell for each other Golem that spell could target. Each copy targets a different one of those Golems.

3/3

225/249 R
MM2 • EN Chippy
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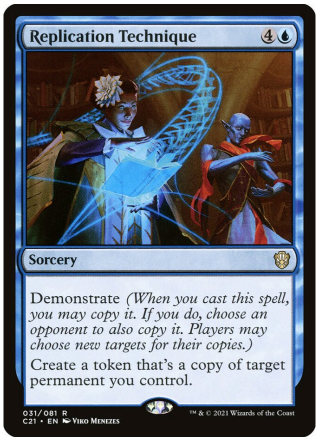

Replication Technique 4

Sorcery

Demonstrate *(When you cast this spell, you may copy it. If you do, choose an opponent to also copy it. Players may choose new targets for their copies.)*

Create a token that's a copy of target permanent you control.

031/081 R
C21 • EN Viko Menezes
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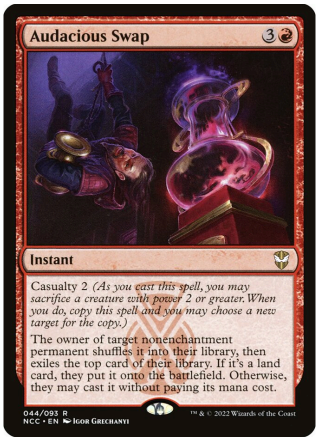
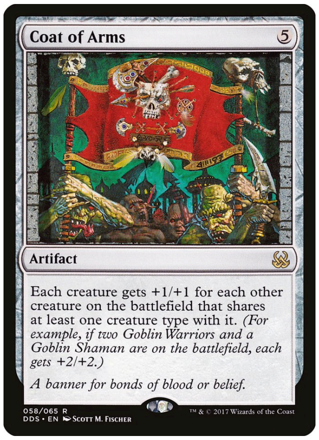


Audacious Swap 3

Instant

Casualty 2 *(As you cast this spell, you may sacrifice a creature with power 2 or greater. When you do, copy this spell and you may choose a new target for the copy.)*

The owner of target nonenchantment permanent shuffles it into their library, then exiles the top card of their library. If it's a land card, they put it onto the battlefield. Otherwise, they may cast it without paying its mana cost.



Coat of Arms 5

Artifact

Each creature gets +1/+1 for each other creature on the battlefield that shares at least one creature type with it. *(For example, if two Goblin Warriors and a Goblin Shaman are on the battlefield, each gets +2/+2.)*

A banner for bonds of blood or belief.

058/065 R
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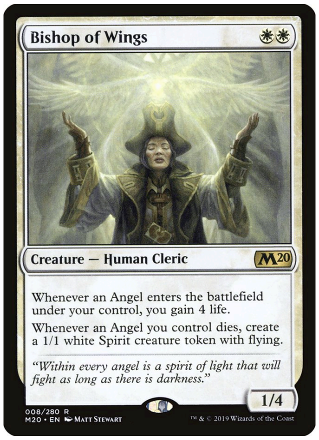

Bishop of Wings

Creature — Human Cleric

Whenever an Angel enters the battlefield under your control, you gain 4 life.

Whenever an Angel you control dies, create a 1/1 white Spirit creature token with flying.

"Within every angel is a spirit of light that will fight as long as there is darkness."

1/4

008/280 R
M20 • EN Matt Stewart
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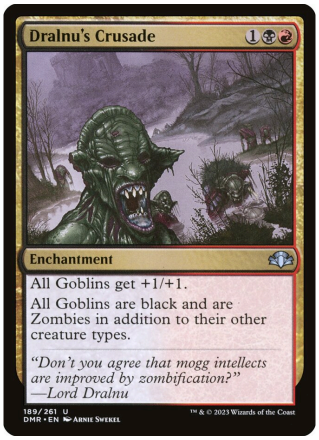

Dralnu's Crusade 1

Enchantment

All Goblins get +1/+1.

All Goblins are black and are Zombies in addition to their other creature types.

"Don't you agree that mogg intellects are improved by zombification?"
—Lord Dralnu

189/261 U
DMR • EN Arnie Swekel
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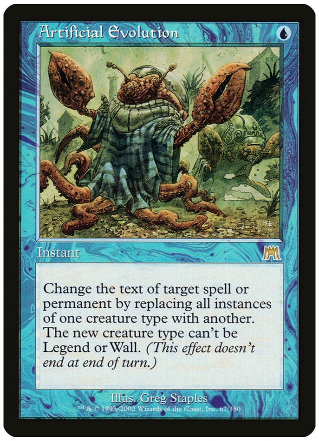

Artificial Evolution

Instant

Change the text of target spell or permanent by replacing all instances of one creature type with another. The new creature type can't be Legend or Wall. *(This effect doesn't end at end of turn.)*

Illus. Greg Staples
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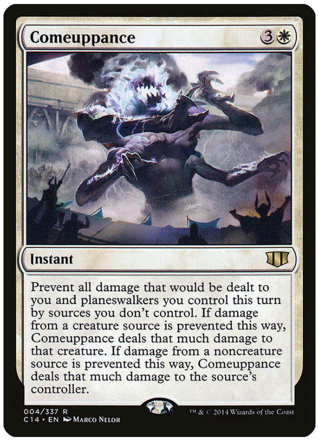

Comeuppance 3

Instant

Prevent all damage that would be dealt to you and planeswalkers you control this turn by sources you don't control. If damage from a creature source is prevented this way, Comeuppance deals that much damage to that creature. If damage from a noncreature source is prevented this way, Comeuppance deals that much damage to the source's controller.

004/337 R
C14 • EN Marco Nelor
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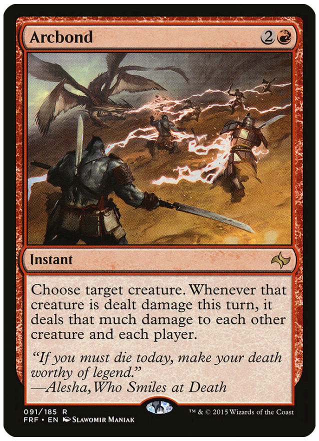

Arcbond 2

Instant

Choose target creature. Whenever that creature is dealt damage this turn, it deals that much damage to each other creature and each player.

"If you must die today, make your death worthy of legend."
—Alesha, Who Smiles at Death

091/185 R
FRF • EN Slawomir Maniak
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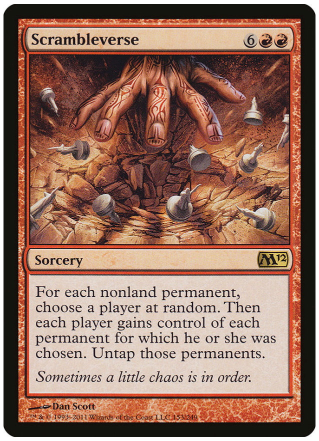

Scrambleverse 6

Sorcery

For each nonland permanent, choose a player at random. Then each player gains control of each permanent for which he or she was chosen. Untap those permanents.

Sometimes a little chaos is in order.

Dan Scott
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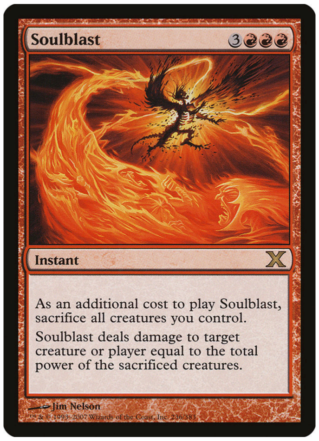

Soulblast 3

Instant

As an additional cost to play Soulblast, sacrifice all creatures you control.

Soulblast deals damage to target creature or player equal to the total power of the sacrificed creatures.

Jim Nelson
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1. Black Lotus
2. Channel
3. Vessel of Endless Rest
4. Precursor Golem
5. Replication Technique
6. Audacious Swap
7. Coat of Arms
8. Bishop of Wings
9. Artificial Evolution

10. Comeuppance
11. Arcbond
12. Dralnu’s Crusade
13. Scrambleverse
14. Soulblast

This is the biggest and most complicated of the decks here. See if you can make any guesses about what to expect.

Ready? Let’s take it from the top.

Start with Black Lotus and Channel. Like before, we can spend 19 life to reach 20 mana, although we’ll have some left over.

Spend 8 mana to play Vessel of Endless Rest and Precursor Golem. Vessel returns one of the previous cards to our library - it won’t matter which. Precursor Golem comes with two regular 3/3 golem tokens.

Tap Vessel for blue mana and play Replication Technique, targeting Vessel. We’ll copy it with Demonstrate, which also lets the opponent copy it, but they don’t have anything to copy. The Demonstrate copy makes a second Precursor, which makes another pair of regular golems.

If we’d had the original Technique spell target one of our golems, we’d trigger Precursor’s ability, copying it for all of them. But we want to make a Vessel token that can tuck back Technique, and we can’t do that with a copy, since then we’d get the Vessel before the original Technique hits the graveyard. So we’re forced to use the main Technique on Vessel and the Demonstrate copy on Precursor, and the copy doesn’t trigger Precursor since it wasn’t cast. We’ll keep having to do it this way most of the times we replay Technique.

Use the new Vessel to tuck Technique, then tap it for red mana to play Audacious Swap. Target a regular golem, getting two Precursor triggers that will copy it for each other golem. But first, we’ll use its Casualty ability, sacrificing one of the regular golems to copy Audacious Swap. With the copy, shuffle back Vessel, letting us play a random card from our library. Due to perfect luck, the card we’ll flip is Technique.

Vessel is in our library, so this is the one time we get to point the main Technique at a golem. This gets two Precursor triggers of its own, but before resolving them, we can use Demonstrate to make another Precursor copy.

At this point, we have three Precursors and five regular golems, one of which has Technique pointed at it. Resolve the first Precursor trigger to copy three Precursors and four golems - the Precursors come with another six regular golems of their own, for a total of 6 Precursors and 15 regular. Then resolve the second Precursor and the original Technique, copying all of the resulting creatures to reach 12 Precursors and 42 regular golems.

Next, resolve the first Precursor-Swap trigger. We won't get one for the golem targeted by the main Swap, but we do get copies for the others. This gives us 53 Swaps to use for this step.

Resolve one Swap, giving up a golem token to shuffle our library and flip Vessel from the top. Use it to tuck Technique so we'll be able to continue playing it. Then use three more Swaps to play Coat of Arms, Bishop of Wings, and Dralnu's Crusade. 49 left.

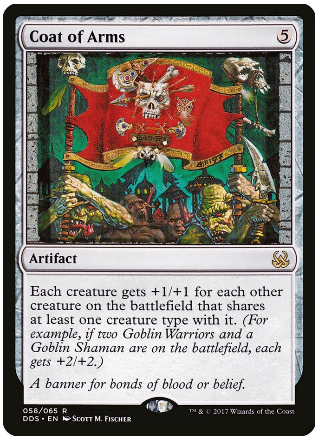
Next, we need to make some copies. We'll replay Replication Technique 29 times, each time using the main cast to copy a Vessel that will put Technique back into the library, while using Demonstrate to make 24 copies of Bishop of Wings, 3 copies of Dralnu's Crusade, and 2 copies of Precursor Golem. Each Precursor comes with two regular golems, so we have 6 golems that *don't* have Swaps pointed at them, as well as 25 Bishops, 4 Crusades, and 20 remaining Swaps.

These Bishops and Crusades will form the backbone of our program, but for it to work properly, we'll need more variety. Play Artificial Evolution from the library, targeting a Dralnu's Crusade to change a creature type listed on it, and replace "Goblins" with "Humans". Then use Replication Technique to make two Vessels, putting back both Technique and Artificial Evolution, and replay Evolution on the same Crusade to replace "Zombies" with "Golems". It now says "all Humans are Golems", meaning our Bishops are included in Precursor's spell-copying effect. 17 Swaps left.

We'll leave one Crusade on "all Goblins are Zombies" and repeat this process on the other two. It doesn't really matter what creature types we pick, as long as we aren't using them elsewhere. Let's say one becomes "all Vampires are Warriors" and the other becomes "all Horrors are Druids". This requires playing Artificial Evolution four times and therefore playing Replication Technique four times to get it back to the library, so we've got 9 Swaps left.

We still need to edit the Bishops, but this step is easier. Use Technique to get back Artificial Evolution, then play Artificial Evolution targeting one of the regular golems, causing all the Precursors to trigger. This lets us apply multiple instances of Artificial Evolution to each of our golems, including the Bishops, to rearrange *all* the types on each of them, or at least as many as we need to. 7 Swaps left.

As for what to change them to, we're aiming for the construction outlined here by Iijil, or an equivalent. Which means it's time to talk about what all of this will actually accomplish.

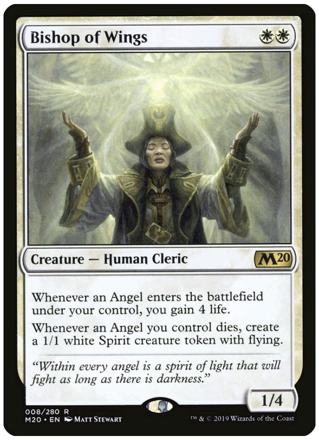


Coat of Arms 5

Artifact

Each creature gets +1/+1 for each other creature on the battlefield that shares at least one creature type with it. *(For example, if two Goblin Warriors and a Goblin Shaman are on the battlefield, each gets +2/+2.)*

A banner for bonds of blood or belief.



Bishop of Wings

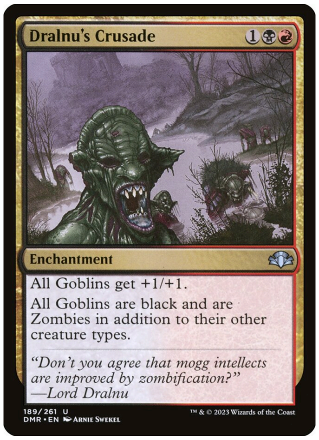
Creature — Human Cleric

Whenever an Angel enters the battlefield under your control, you gain 4 life.

Whenever an Angel you control dies, create a 1/1 white Spirit creature token with flying.

"Within every angel is a spirit of light that will fight as long as there is darkness."

1/4



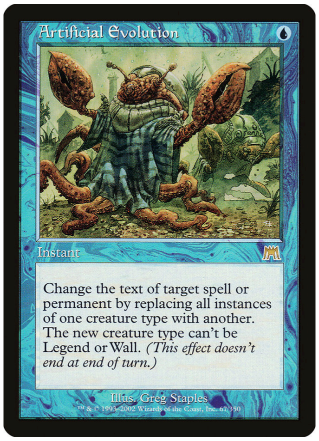
Dralnu's Crusade 1

Enchantment

All Goblins get +1/+1.

All Goblins are black and are Zombies in addition to their other creature types.

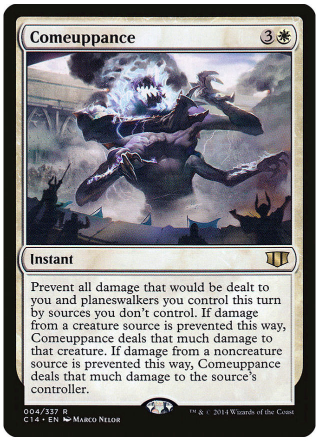
"Don't you agree that mogg intellects are improved by zombification?"
—Lord Dralnu



Artificial Evolution

Instant

Change the text of target spell or permanent by replacing all instances of one creature type with another. The new creature type can't be Legend or Wall. *(This effect doesn't end at end of turn.)*



Comeuppance 3

Instant

Prevent all damage that would be dealt to you and planeswalkers you control this turn by sources you don't control. If damage from a creature source is prevented this way, Comeuppance deals that much damage to that creature. If damage from a noncreature source is prevented this way, Comeuppance deals that much damage to the source's controller.

004/337 R
C14 • EN Marco Nelor
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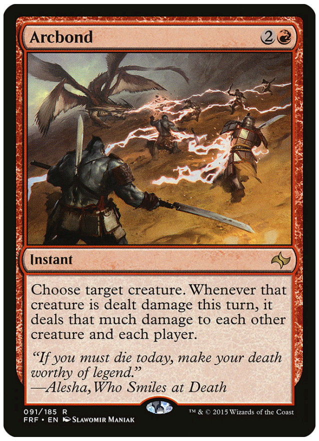

Arcbond 2

Instant

Choose target creature. Whenever that creature is dealt damage this turn, it deals that much damage to each other creature and each player.

"If you must die today, make your death worthy of legend."
—Alesha, Who Smiles at Death

091/185 R
FRF • EN Slawomir Maniak
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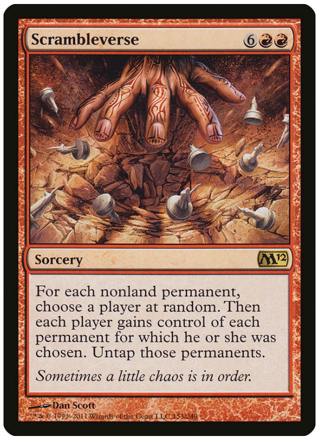
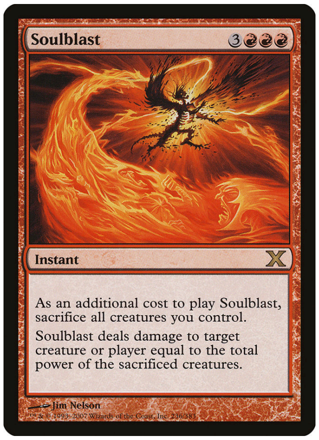
With a lot of hacked Bishops, we're able to generate a lot of tokens of specific creature types. Thanks to Coat of Arms, each of those creatures gets a stat boost based on the number of others with the same type, and in particular, a boost to their toughness. This is important because we generate tokens when the existing creatures die, and we need to control when that happens.

Our primary damage source is Arcbond+Comeuppance. By putting Arcbond on a creature and then dealing damage to it, it deals that much damage to all the other creatures, as well as each player. Meanwhile, playing Comeuppance means that every time the creature hits us, we can redirect that damage back to itself, causing it to get another Arcbond trigger. This will continue until the Arcbonded creature dies, and we want to make that take a very long time.

Now, we've established how we keep the Arcbond damage from killing ourselves. But how do we keep the opponent alive? Also, what's the initial damage source, and what keeps this from going infinite?

The answers are in the final pair of cards:


Scrambleverse
Sorcery
For each nonland permanent, choose a player at random. Then each player gains control of each permanent for which he or she was chosen. Untap those permanents.
Sometimes a little chaos is in order.
Dan Scott


Soulblast
Instant
As an additional cost to play Soulblast, sacrifice all creatures you control.
Soulblast deals damage to target creature or player equal to the total power of the sacrificed creatures.
Jim Nelson

It would be easy to set up a couple copies of Bishop of Wings to keep churning out tokens forever, making a loop that never stops on its own. But in order to turn that into an infinite score, we'd need a way to translate that unbounded loop into unbounded damage, and this deck is built to have no way of doing that. The only way for us to start this chain of Arcbond triggers is to use Scrambleverse to move any relevant creatures to the opponent's side of the field, then use Soulblast to sacrifice one or more expendable creatures we've left on our own side to damage the Arcbond creature. This ensures that, while our machine is running, we don't have any Bishops on our own field.

If we did control the Bishops, we would be able to control whether the Bishop triggers or the damage triggers would resolve first, allowing us to end the program by delaying the triggers that create the tokens needed to keep the Arcbonded creature alive. But because the Bishops are under the opponents' control while the damage triggers are under our control, the Bishop triggers must go on the stack second and resolve first.

We also don't have any opportunities to play an instant to interrupt the program, since we need to play all our instants before starting the program, and we have no way to get them back to our hand. We have to replay them with Audacious Swap, which only lets us play the spells at the exact moment a Swap resolves, and any Swaps we've queued up before starting the program won't resolve until after the program finishes. So the only way for us to get out of the program and reach the point where we can translate its output to damage is to build a program that will end on its own.

Having the creatures under the opponent's control also takes care of the matter of the opponent's life total, since they keep gaining life from Bishop of Wings triggers, faster than Arcbond will take it away. But we'll be able to do even more damage at the end.

Now, let's look at the specific program we're writing:

- Startup:
    - Bishop (Boar Boar) with Boar to Kavu
    - Vanilla (Boar)

- Output:
    - 4x Vanilla (Drake)
    - Bishop (Kavu Drake) with Drake to Golem
- Input:
    - 2x Vanilla (Kavu)
- Input Heartbeat:
    - Vanilla (Crab)
    - Bishop (Kavu Horror) with Crab to Crab
    - Bishop (Kavu Horror) with Crab to Kavu
    - 2x Bishop (Kavu Horror) with Crab to Drake
- Part-Flooding Clock 4:
    - Dralnu's Crusade (Horrors are Druids)
    - Vanilla (Horror)
    - Bishop (Kavu Horror) with Horror to Horror
    - Bishop (Kavu Horror) with Horror to Crab
    - Bishop (Kavu Horror) with Druid to Druid
- Heartbeat for Clock 4:
    - Bishop (Kavu Horror) with Frog to Frog
    - Bishop (Kavu Horror) with with Frog to Druid
- Part-Flooding Clock 3:
    - Dralnu's Crusade (Vampires are Warriors)
    - Vanilla (Vampire)
    - Bishop (Kavu Horror) with Vampire to Vampire
    - Bishop (Kavu Horror) with Vampire to Frog
    - Bishop (Kavu Horror) with Warrior to Warrior
- Heartbeat for Clock 3:
    - Bishop (Kavu Horror) with Ape to Ape
    - Bishop (Kavu Horror) with Ape to Warrior
- Part-Flooding Clock 2:
    - Dralnu's Crusade (Goblins are Zombies)
    - Vanilla (Goblin)
    - Bishop (Kavu Horror) with Goblin to Goblin
    - Bishop (Kavu Horror) with Goblin to Ape
    - Bishop (Kavu Horror) with Zombie to Zombie
- Heartbeat for Clock 2:
    - Bishop (Kavu Horror) with Cat to Cat
    - Bishop (Kavu Horror) with Cat to Zombie
- Part-Flooding Clock 1:
    - Dralnu's Crusade (Humans are Golems)
    - Vanilla (Human)
    - Bishop (Kavu Horror) with Human to Human
    - Bishop (Kavu Horror) with Human to Cat
    - 2x Bishop (Kavu Horror) with Golem to Golem

All 25 Bishops are accounted for here, as well as 12 “vanilla” creatures that can either be Precursors or the tokens they create. At the moment, we have a total of 14 vanillas: 6 new ones that aren’t being targeted, 7 with the remaining Swap copies, and one with the original Swap. The original Swap won’t resolve soon enough to matter, so we can have the one with the original Swap join the 6 new ones in the main part of the program. For the remaining ones being targeted by Swap copies, the four set to resolve last will need to be Drakes so they can survive as part of the program’s output, while the other three can be… anything, really, but we’ll call them Boars.

Resolve the next two Swaps, giving up two Boars to play Arcbond, targeting one of the vanillas that became a Kavu, and Scrambleverse. Scrambleverse randomly selects a controller for each creature on the field, and with perfect luck, we’ll have the opponent take control of everything except the “Boar” Bishop. Note that we still own the tokens that were created under our control, which is what matters for Audacious Swap. 5 Swaps left.

We do have one card left in hand - Comeuppance, which we can play now. Then resolve the last Boar Swap, allowing us to play Soulblast.

Soulblast sacrifices all our creatures, which is now a single Bishop. With our other Boars gone, it’s back down to its normal 1 power, so we can deal 1 damage to a target, and we’ll pick the Kavu with Arcbond on it. At this point, our chain reaction comes to life.

Arcbond triggers, and the Kavu deals 1 damage to each other creature and each player. Comeuppance prevents the damage to ourselves, and deals 1 damage back to the Kavu. This sets off the Kavu’s Arcbond a second time, then a third time.

At the third time, interesting things start to happen. All the creatures now have 3 damage marked on them - and between Coat of Arms and Dralnu’s Crusade, most of them can survive that, but the Crab vanilla can’t, since it’s a 3/3 that isn’t receiving any sort of boost. It dies, triggering the four Bishops keyed to Crabs: one to make a new Crab, one to make a Kavu, and two to make Drakes. These Kavus and Drakes add toughness to our Bishops and vanillas, helping to keep them alive. All the new tokens are 1/1s, which is important since it means that each damage trigger will kill our Crab and repeat this process - for now.

Go to the fourth “tick” of our clock. Once again, we kill a Crab, making a new Crab, a Kavu, and two Drakes. We also kill the vanilla Vampire, Goblin, and Human, since their respective Dralnu’s Crusades had made them all 4/4s. The Vampire is also a Warrior, so its death creates a new Vampire Warrior, a Frog, and a regular Warrior. Similarly, the Goblin (which is also a Zombie) gives us a new Goblin Zombie, an Ape, and a regular Zombie, while the Human (also a Golem) gives us a new Human Golem, a Cat, and two regular Golems.

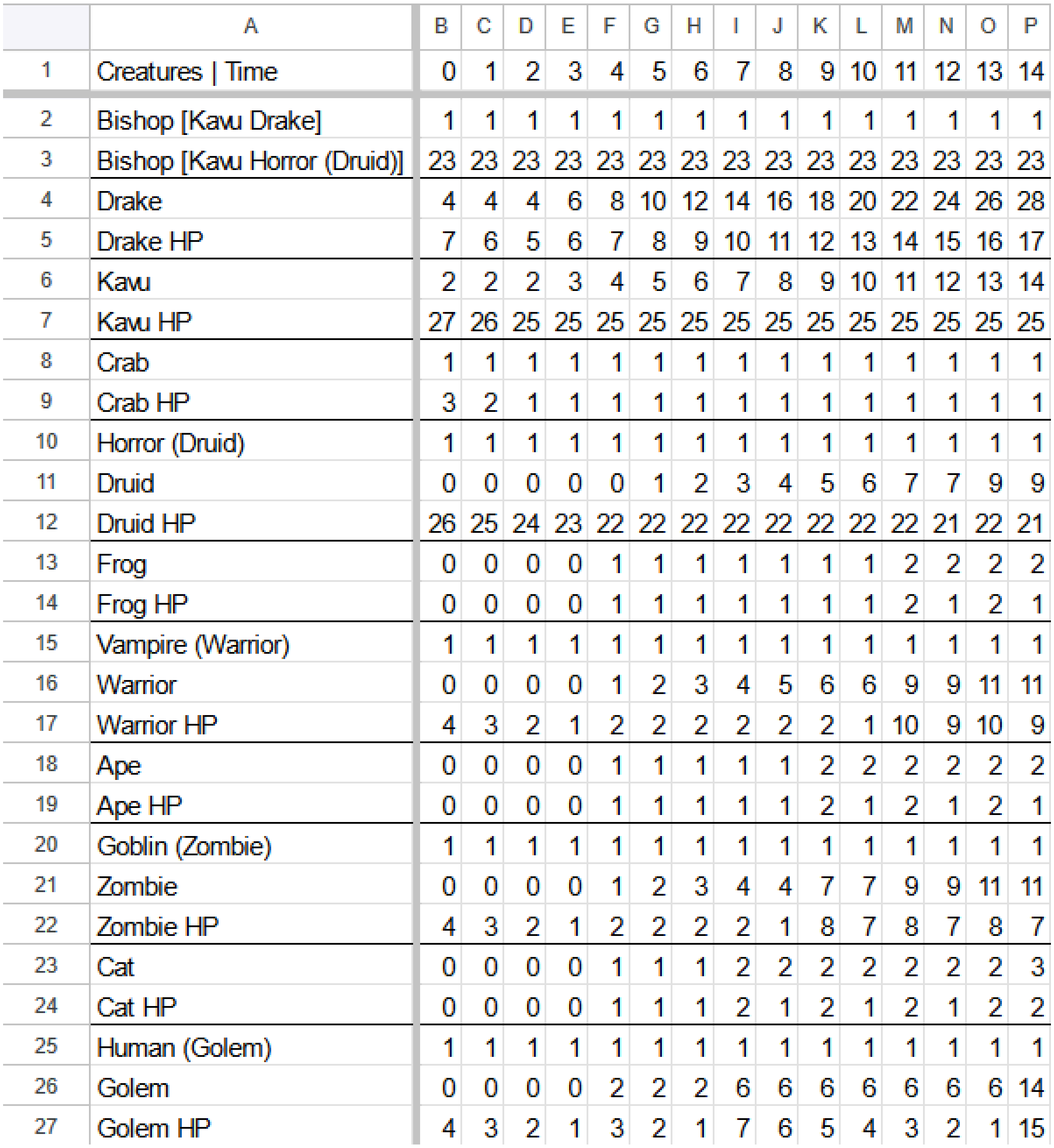
(Note that while I talk about “us” having these creatures, all these creatures are still under the control of our opponent, since we had to empty our own side of the field. This also means the opponent is the one gaining life from the Bishop triggers, keeping them from dying to Arcbond damage. We don't have to worry about our own life total because of Comeuppance.)

Go to the fifth tick. The creatures that share creature types with others will have enough toughness from Coat of Arms to survive, but the Crab will do its thing again - and we'll also kill the Frog, Ape, and Cat, causing their associated "heartbeat" Bishops to replace them and make a Druid, Warrior, and Zombie. These "heartbeat" effects will keep repeating each time we kill the associated creature, which so far is every tick, but it won't stay that way.

Two more ticks. Each tick gives us a new Warrior and a new Zombie, which gives the old ones the toughness they need to stay alive, but we're not getting new Golems. On the seventh tick, the two regular Golems die. This triggers the associated Bishops, but before they can make more Golems, the Human Golem's toughness drops enough that it dies as well. The associated Bishops create a new Human Golem, another Cat (bringing us to two Cats), and six regular Golems. This is the "flooding" of this part-flooding clock, the point where it overflows and spills into the Cat heartbeat clock.

Having a second Cat means they're both 2/2s, so we're no longer killing and replacing one Cat and getting a Zombie at every tick, we're now killing and replacing two Cats and getting two Zombies at every second tick. The number of Cats stays constant at two (until the Golem clock floods again) and we're still getting an average of one Zombie per tick, but this gap between heartbeats turns out to be significant.

To understand why, let's take a full look at the board over the ticks so far, and the next few:



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Creatures | Time	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2	Bishop [Kavu Drake]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	Bishop [Kavu Horror (Druid)]	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
4	Drake	4	4	4	6	8	10	12	14	16	18	20	22	24	26	28
5	Drake HP	7	6	5	6	7	8	9	10	11	12	13	14	15	16	17
6	Kavu	2	2	2	3	4	5	6	7	8	9	10	11	12	13	14
7	Kavu HP	27	26	25	25	25	25	25	25	25	25	25	25	25	25	25
8	Crab	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	Crab HP	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1
10	Horror (Druid)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	Druid	0	0	0	0	0	1	2	3	4	5	6	7	7	9	9
12	Druid HP	26	25	24	23	22	22	22	22	22	22	22	22	21	22	21
13	Frog	0	0	0	0	1	1	1	1	1	1	1	2	2	2	2
14	Frog HP	0	0	0	0	1	1	1	1	1	1	1	2	1	2	1
15	Vampire (Warrior)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	Warrior	0	0	0	0	1	2	3	4	5	6	6	9	9	11	11
17	Warrior HP	4	3	2	1	2	2	2	2	2	2	1	10	9	10	9
18	Ape	0	0	0	0	1	1	1	1	1	2	2	2	2	2	2
19	Ape HP	0	0	0	0	1	1	1	1	1	2	1	2	1	2	1
20	Goblin (Zombie)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	Zombie	0	0	0	0	1	2	3	4	4	7	7	9	9	11	11
22	Zombie HP	4	3	2	1	2	2	2	2	1	8	7	8	7	8	7
23	Cat	0	0	0	0	1	1	1	2	2	2	2	2	2	2	3
24	Cat HP	0	0	0	0	1	1	1	2	1	2	1	2	1	2	2
25	Human (Golem)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	Golem	0	0	0	0	2	2	2	6	6	6	6	6	6	6	14
27	Golem HP	4	3	2	1	3	2	1	7	6	5	4	3	2	1	15

Most of these rows track the number of creatures, but the HP rows show how close those creatures are to death. Specifically, it's the toughness of those creatures after applying Coat of Arms and Dralnu's Crusade, minus the damage currently marked on them. Different creatures within a group may have different amounts of damage, but all that matters is the HP of the one that's closest to death. When that creature dies, it takes away the bonuses it was granting the others through Coat of Arms, shrinking them and killing whatever was next closest to death. Each time, this will ultimately kill all the creatures in that batch. The one group that's never in danger is the Drakes, because their numbers grow faster than the damage they take.

When we made the second Cat at tick #7, the Zombie clock had stabilized at 2 HP, because the first regular Zombie was a 5/5 with 3 damage marked on it. Previously, on each tick, that Zombie would take 1 damage, then grow by +1/+1 from the creation of a new Zombie. But because the Cat heartbeat has changed to every other tick, we don't get new Zombies until tick #9. Before that tick's token creation triggers can resolve, that Zombie is a 5/5 with 5 damage, so it dies and takes all the other Zombies with it. This includes the Goblin Zombie, which dies and creates a new Goblin Zombie along with a second Ape. This is the Zombie clock's "flooding" event.

We get a new batch of Zombies, which are no longer at constant HP. They start at 8, drop to 7 on ticks when no new Zombies are created, then go back up to 8 when the Cat heartbeat resupplies them with more Zombies. This repeats as long as we have two Cats. Eventually - on tick #14 - the Golem clock will flood again and make a third Cat. When the Cat clock reaches a three-tick cycle, the Zombie clock starts alternating between 8/7/6. And when we get our fourth Cat, the Zombie clock's HP cycle will become 8/7/6/5.

It will take 8 Cats for a big enough gap that the Zombie clock floods again. This will take a while, since each time a batch of N Golems dies (including one Human Golem), we go up to a total of 2N+1 Golems, which means another 2N+1 ticks until the Golem clock floods again and creates the next Cat. Which means more time to accumulate Drakes.

In the meantime, the Apes and Warriors go through the same thing. The Warriors had stabilized at 2 HP, but having a second Ape means the Warriors die at the same time as the pair of Apes do, causing the Warrior clock to flood and create a second Frog.

The Frogs control the Druid clock, but there isn't the same immediate effect. The Druids have a bunch of extra toughness from sharing a creature type with most of the Bishops, so the Druid clock won't flood until we have 22 Frogs. When the Druid clock does flood, it creates the creature type that ends up as our final limiting factor: a Crab.

Once we have multiple Crabs, we're no longer creating Kavus on every tick, so the Kavu HP starts to cycle. And the Kavu with Arcbond on it stabilized at 25 HP, so once we have 25 Crabs, the Arcbond Kavu will die, and the chain reaction will finally end.

But how long will this take? The longer it takes to finish, the more Drakes we get - as long as it ends eventually, so we can finally make use of them.

In order to get N Cats, we need the Golem clock to flood N times. Each time, it will take over twice many ticks as the previous time, so N Cats means over 2^N ticks.

In order to get N Apes, we need the Zombie clock to flood N times. Whenever the Zombie clock floods from reaching X Cats, we must have passed 2^X ticks since we started generating Cats and Zombies, which means our total Zombie count will have increased to at least 2^X. This means the next Zombie clock flooding will require 2^2^X ticks, and the one after that will require 2^2^2^X ticks. In other words, N Apes means over 2^^N ticks.

Getting N Frogs requires flooding the Warrior clock N times. This requires repeatedly accumulating Apes in the same way, so it will take over 2^^^N ticks. And finally, getting N Crabs requires flooding the Druid clock N times, which requires repeatedly accumulating Frogs, over the course of 2^^^^N ticks. Each set of clocks constitutes another layer, which gives us another Knuth arrow.

This means the point when we hit 25 Crabs is after over 2^^^^25 ticks. At this point, all the non-Bishop Kavus die, including the one with Arcbond on it, causing the chain reaction to stop. (The Bishops have additional toughness from their other creature types.) We've accumulated over 2^^^^25 Drakes, as the output for our program.

Wait, all that for just 2^^^^25? That's nothing to us, by now. We could get more than that with just seven cards. Why go to all that trouble?

The answer, of course, is that we're still just setting up.

When we cast the original Audacious Swap, we got two Precursor-Swap triggers. Resolving one of those gave us the 53 Swaps that allowed us to build our first program. But the other one has stayed on the stack this whole time.

Now that the first program has ended, we can start resolving the rest of the stack. But before we reach the remaining Precursor-Swap trigger, we need to make sure we can make use of it. The first problem is that it wants to copy Swap for each Golem on the field, and what we made is a bunch of Drakes. We also need to make sure the tokens we're targeting with Swap are tokens we created under our own control so we're the ones that own them. Most of the current Drakes were created under the opponent's control, so targeting them with Swap would give the Swaps to the opponent rather than to ourselves.

Fortunately, we saved four Swaps from earlier, turning the creatures they were targeting into Drakes so they would survive this whole program. It's time to finally make use of them.

Resolve the first two Swaps, first playing Replication Technique to make two Vessels and tuck itself and Scrambleverse, then play Scrambleverse. Take control of all the Drakes, including the Drake Bishop