The Physics of Zombies: Madore's Rules of Zombie Cohesion, Zombie Cells and Super Cells, Zombie Black Holes, Zombie Cell Stress-Fission and Zombie Quirks

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I. Abstract

Madore's Rule of Zombie Cohesion states that zombie cells will form as a result of zombie food/prey alert signals that create a zombie cohesive field that attracts zombies. It is our contention that once such cells form, they may continue to grow into zombie super cells unless acted upon by either attrition (due to acts, obstacles and nature) or split during zombie cell stress-fission into smaller cells. A zombie super cell may eventually form a zombie black hole and all free-roaming zombies capable of reacting to a zombie alert signal may be absorbed into said zombie black hole. We *must* prepare.

Keywords: Zombies, Apocalypse, Big Bite, Black Holes, Rule of Cohesion

1. Introduction

We begin this paper with the notion that there has been a critical error in current thinking and modeling of the effects of a mass zombie infection and outbreak. Current modeling holds that zombies will act as either individual predators that seek out prey and then either consume and/or "turn" (pass infection along to) said prey, or, gather in groups that disperse after an arbitrary time (usually after prey has been captured, consumed or turned).

We believe that a zombie apocalypse will be *much* worse than anyone has currently proposed or modeled. In addition to the utter horror of dealing with the undead face-to-undead face, we can also look forward to dealing with potential "zombie black holes" whose member components may stretch into the millions.

It must be noted that it is beyond the scope of this paper to detail zombie virus characteristics, vectors of transmission, sustainability of individual undead necro-masses and other similar characteristics of the zombie plague.[1] Other necropologists are busy at work dealing with the parameters of an initial zombie plague, carriers and transmission. Rather, we hope to illustrate grouping scenarios that will exist after a sufficient number of people have been turned into the raging undead that we know so well.

Our research has led us to the inevitable conclusion that an all-important aspect of zombie behavior has been overlooked by scientists and the lay public alike. Specifically, that zombies signal to each other and that this signal is a powerful attractant and cohesive force, akin to gravity. Further, we believe that in certain inevitable scenarios, zombie alert signals may outlast the original signal source and create a resonance that continues to attract zombies and hold them in place. In turn, this signal amplification and resonance will hold zombies in place and the signal will further increase as the numbers of zombies held grows, diminishing only due to group attrition.

We believe that zombies, after infection, display behavior that properly belongs within the field of physics. Zombies are essentially animate objects that are slaves to forces that resemble conventional physical laws and mechanics. While the whole of their study falls within the field of necropology, we believe that our current body physics knowledge can shed much needed light onto predictions of zombie movement and massing, thus increasing humanity's chances of survival during a zombie apocalypse.

In this paper we will detail the physics and mechanics of Madore's Rule of Zombie Cohesive Force and the resultant groups that force causes to form. We believe that said Rule may lead to zombie black holes that have cohesive properties so great that only zombie alert signals may escape the zombie event horizon. Zombies and the unfortunate prey at the center of such a black hole have little to no chance of ever seeing an end to the concentration of necro-flesh that such phenomena would create.

Where conventional wisdom predicts that cities must be avoided due to their abundant prey populations (and hence the probability of zombie hordes massing) we believe that a zombie black hole could find its center of propagation *anywhere* a sufficient zombie signal starts and replicates. Vigilance and action must be taken to keep zombie cells, super cells and black holes from forming. In essence, all areas are at danger of said black holes, urban and rural alike, and we are all at risk.

Again, we *must* prepare.

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[1] There is debate among necropologists over the proper taxonomy of zombie flesh. Preference here is given to the term "necro-mass" over "bio-mass."

1.1 Axioms and basic descriptions of zombie behavior

The reader may or may not be aware of the specifics of zombie behavior. We will first attempt to illustrate basic zombie behavior and then how, once turned, zombies arrange and array themselves according to rules and principles of physics.

Firstly, we are *not* concerned in this paper with re-animated corpses that derive their life-force from mystical sources.[2] Rather, we are concerned with the autonomous zombies that all too often result from viral infection, commonly called "Biters." Biters tend to exhibit specific behavior that forces them into repetitive actions mainly focused on scouting for prey, chasing prey and alerting other zombies to prey locations.

As most researchers and lay people know, zombies hunger for human flesh. While certain zombies prefer brains, others seem to be ceaseless gourmands of human flesh and will bite any area of human flesh exposed to their maw. Zombies will tirelessly seek out human flesh or travel to what they believe to be locations that contain human flesh.

Let us now take a look at the most basic of zombie actions and characteristics of an individual zombie:

> A) Once bitten and turned, a zombie will seek out human flesh to bite, which in turn creates another zombie.
> B) A zombie will follow prey relentlessly, even risking its own destruction in an attempt to attack, consume or turn prey.
> C) Zombies send out an alert signal when they sight prey, usually in the form of a moan or other more articulate utterance.
> D) A zombie otherwise not engaged in either attacking or stalking previously sighted prey will travel towards an alert signal given out by another zombie and will add its own signal to the din created by the first signaling zombie.
> E) As long as the alert signal is given by any zombie, other zombies will attempt to reach the source of the signal and carry out their own capture of the prey being signaled upon.
> F) If no signals or attractant prey are present, zombies generally carry out random-seeming strolls or simply stand immobile. They may also engage in mindless tasks such as wandering into alleys and "hiding" in abandoned houses.[3]

We will now refer to this prey alert signal as a "zombie noise constant" or Zn, as it is constant once prey is sighted and is constantly attractive to other zombies for the duration of the signal. If prey is spotted, a zombie is constant in its actions. Once heard, it cannot

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[2] Mystical zombies usually derive their power from spells and incantations that draw them forth from the grave. They do not bite and turn others while on their missions. This category includes certain golems and other master-driven undead. We do, of course, make exception for the mass rising of the undead from their graves during a spiritual apocalypse, indeed, they might possibly also turn and infect others; if so, then they are included in the zombie behavior and physics organization detailed in this paper.

[3] They seem to really "enjoy" old farmhouses, remote cabins, dark alleys, abandoned cars, etc.

be ignored except by zombies already giving off their own signal while engaged in the "hot pursuit" of their own prey.

2. Zombie Cohesion

When Zn is present, every zombie attracts every other zombie with a force pointing along a line that intersects both zombies. The force of the attraction is proportional to the product of the two zombies (or masses of zombies) and inversely proportional to the square of the distance between them, as follows:

$$ZCF = Zn \, (Zm_1 * Zm_2 / r^2)$$

Where

ZCF is the zombie cohesive force between the zombie masses,
Zn is the zombie noise constant,
Zm_1 is the first zombie mass,
Zm_2 is the second zombie mass and
r^2 is the distance between the masses

Thus, we can see that zombies naturally cohere with a force akin to gravity. The larger the mass of zombies, the stronger the cohesive force exerted upon the masses within the system. Proximity, too, plays a role. Zombies at short range find the siren call of other zombies irresistible. As we shall see in the following sections, this cohesive force leads to some very startling arrangements of zombies on the prowl.

2.1 Phase I: The Big Bite

Zombie infestations may begin with but a singular bite of one zombie on one human. We refer to this moment of singular bite, or singularity of bite, as the "Big Bite."

At the start of any zombie physics model, $Zn = 0$ as there is only one zombie. This is the ideal moment to stanch any continued propagation of the plague and as $ZCF = 0$ it can be easily overcome. Alas, this is usually the moment that disbelief in (or fear of) zombies steps into the picture and the plague breaks loose.

As soon as one zombie turns another zombie, one can say that the Big Bite has ended.

Formulaically, we now have $Zn > 0$ and $ZCF > 0$ and this is the start of all of the trouble.

At this point, it is instructive to turn to the notion of how many zombies one might be dealing with after a Big Bite event. We must turn to a notion of zombie chain reactions and "zombie avalanches"[4] that are created from a single bite, which expressed mathematically, is as follows:

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[4] This is akin to electron avalanches in the humdrum world of physics.

$$Z = 1 / 1 - (Zb / Zatr)^P$$

Where

Z is the total number of zombies created from a big bite event,
Zb is the zombie bite rate,
Zatr is the zombie attrition rate, and [5]
P is the number of human prey available

Clearly we can see that as the zombie bite rate nears the zombie attrition rate; the only limiting factor is the number of humans, P, that are available for consumption and turning. In other words, an unchecked Big Bite quickly turns into a zombie critical mass according to regular physics![6]

Once multiple zombies are formed, ZCF begins to take on a major deterministic role in the type of zombie horde that surviving humans will be forced to encounter.

Let us proceed to Chaos Clouds.

2.2 Phase II: Chaos Cloud

If a zombie outbreak occurs in an area where there are multiple prey sources in multiple directions we achieve a state in which $Zn > 0$ and $ZCF > 0$ but the effective cohesive force is nullified as a predictor in determining zombie grouping. Zombies will still be attracted by ZCF; however, due to omni-directional signals, they will be drawn to and fro by conflicting lines of forces forming a "chaos cloud" of zombies. A "chaos cloud" has the following features:

> A) Multiple prey sources
> B) Multiple zombie agents
> C) Short duration prey signals, ending as prey is quickly turned or as zombies are nullified by defenders

Where alignment of ZCF is ever shifting and signals begin and end before zombies can close the gaps between them, and thus, are unable to link up, a chaos cloud exists.

One may examine this thusly as so:

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[5] Zatr, zombie attrition, is a result of zombies being terminated by humans (i.e., "acts of attrition" that include gunshot, decapitation or other immobilizing/terminating events promulgated by humans) and natural obstacles and events that terminate zombies (i.e., zombies falling off cliffs, burning up in forest fires, etc.).

[6] Again, it must be stated that we are not directly concerned with the vectors of transmission and other viral transmission factors. A host of factors affect the ability of zombies to transfer their plague to non-zombies. However, we find it instructive to view the horde at this point as a critical mass of zombies engaged in the wholesale transformation of the prey present. Other necropologists have vastly different notions of how an infection would progress and while we respect such differing opinions, we also politely disagree with them.

Zcc > 1 and,

$$Zcc = (S^n * D^n) / (I^n * Ds^n)$$

Where ,

Zcc is Zombie Chaos Cloud,
S^n is number of signals and n = 1 to infinity,
D^n is direction of signals and n = 1 to infinity,
I^n is intensity of signals and n = 1 to infinity and
Ds^n is duration of signals and n = 1 to infinity

When Zcc is > 1 and ZCF = 1, ZCF cannot alone act as a determinate of zombie velocity or position, the direction of travel is uncertain and zombies dart to and fro on random seeming treks for more prey.

To a causal observer, a chaos cloud has the appearance of a breakdown of ZCF as an attractive force when in reality it is the reverse. One need only ponder what happens when S^n decreases and yet the masses of zombies still rampage around the countryside. Soon, if a single signal survives, the siren song of the ZCF shows its true colors, behold, the cell!

2.3 Phase III: Cell

If one observes a chaos cloud long enough, one will begin to notice groups or clusters of zombies forming. A cell may develop when S^n drops and ZCF starts to come in from a singular direction (or if a zombie hears and responds to a single ZCF, even amidst other signals.) Briefly stated, a cell is the short lived phenomena of two or more zombies drawn together by ZCF.

A cell typically lasts only as long as it takes the cohesed zombies to capture and consume/turn the prey that has been alerted upon. Once a zombie coheres to a cell, or is the center of one, the only formula that applies to his behavior is $ZCF = Zn (Zm_1 * Zm_2 / r^2)$ and/or the capture of prey being alerted upon by the Zn source.

Basically, a cell is what happens when multiple zombies converge on a single prey alert signal, adding their own signal to the originating signal; together they form a zombie alert chorus. As the infection spreads, and prey becomes scarce, one starts to see eddies and swirls of small pockets of zombies acting in concert. For instance, two zombies may see the same prey at the same time. When multiple zombies converge on the same prey, and their combined signal is amplified, they draw in other zombies according to $ZCF = Zn (Zm_1 * Zm_2 / r^2)$ on a single target. Once the prey is consumed – and it is witnessed by

all present – ZCF approaches 0 as Zn approaches 0.[7]

At such time as ZCF = 0, the cell breaks apart. Cell members begin their random wandering again and the chaos cloud may continue.[8]

If no ZCF is present for a long enough period of time, the chaos cloud will lose total coherence and cannot rightly be called a "cloud" any longer. If, however, Zn is > 0 and therefore ZCF is also > 0 for an extended period of time, a cell has a chance of becoming a super cell and then possibly a black hole.

Another feature of cells is that they are also susceptible to being broken apart due to stress-fission (see section 3 below). That is, cells can be pulled apart by external stresses.

We may now say that cells have the following characteristics:

> A) Cells must contain at least two zombie members
> B) Cells must receive Zn (prey signals) to retain cohesion
> C) Cells are short lived events (they either break apart or become super cells)

Let us now turn to super cells and examine what they are all about.

2.4 Phase IV: Super Cell

Simply stated, a zombie super cell is a large, long-lived cell. If conditions are conducive, it is also the intermediary step between simple cell and zombie black hole.

Imagine a scenario in which a chaos cloud forms and zombies dart to and fro, chasing down whatever prey is trapped within the cloud. As prey diminishes, multiple zombies are drawn by fewer and fewer Zn and ZCF starts to cohese groups. Imagine multiple small cells forming and chasing down prey until a single prey signal remains. All zombies within range of the prey alert (*and/or* the alert given by the zombies that have heard the original alert) converge on that signal. Here, cells fuse and form a super cell.

Now, take that same super cell and give it another signal, on the periphery and/or outside of the circumference of the super cell. If the original prey alert ends when the new signal begins, one would see the zombie super cell shift and glide toward the new signal as a cohesive zombie unit.[9]

Essentially, zombie super cells need not be stationary, they might move together and stay chained together as long as prey shows up before the original alert signal diminishes and

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[7] This "witnessing by all" aspect will become very important later in "Section 2.5 Black Hole," and in specific, the "Glass Box" example.

[8] It is important to note that a chaos cloud is not a necessary pre-cursor to cell formation. A zombie chain reaction of one group of zombies, of two or more zombies, serially infecting singular prey is also an example of a cell - a cell that formed without a chaos cloud.

[9] It is a rambling, shambling unit to be sure, but a cohesive one nonetheless. A zombie amoeba flowing across the landscape, devouring and scrubbing it clean of humans while it consumes everything in its path.

evaporates. A zombie super cell may roam across the landscape like a flock of birds or swarm of locusts. A *disgusting, horrific, human-eating* swarm of locusts![10]

Luckily, another feature of super cells is that they are also susceptible to being broken apart due to stress-fission (again, please see section 3 below). Super cells, like all cells, can be pulled apart and diminished by external forces and Zatr (zombie attrition).

If a super cell devours/turns all prey in a given area and no new prey alert signals are given out, or taken up by, the super cell members, it collapses and the members disperse as so: $Zn = 0$, thus $ZCF = 0$.

What happens if there is a continual source of prey alert signals? What if a cell becomes a super cell and then receives a continuous signal alerting the members that a zombie has sighted prey and all zombies must come running and *they,* in turn, spread the word?

Let us examine the thing that the authors dread the most… ZOMBIE BLACK HOLE/S!

2.5 Phase V: Zombie Black Hole/s

A zombie black hole is essentially a group of zombies chasing their own tails (and you, if they can catch you.)

Before one can talk about black holes, one must examine zombie prey alert signals a bit more closely. While all zombie signals provide Zn and thus, ZCF, they need not come from legitimate sightings of prey, or sightings of legitimate prey.

We must return to the Axioms in Section 1, and specifically, Axioms C and D from that section:

> C) Zombies send out an alert signal when they sight prey, usually in the form of a moan or other more articulate utterance.
> D) A zombie otherwise not engaged in either attacking or stalking previously sighted prey will travel towards an alert signal given out by another zombie and will add its own signal to the din created by the first signaling zombie.

We must now add other types of "signal" to those notions. We will examine, visual and audio signals, an array of false signals and signal resonance.

The first thing we can say is that Zombies also take visual cues from other zombies. Zombies can receive, send and respond to visual signals. For example, a zombie that runs past another zombie will soon find the other zombie running behind it, or with it, toward the same point the first zombie is running to. Thus, zombies can also take an alert, or cue, from the *actions* of other zombies.

Essentially, any zombie that appears to be responding to a zombie alert will itself

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[10] Apologies to our entomologist friends, we're sure normal locusts are quite lovely.

be giving off an alert through its actions (i.e., running, pounding on a door, etc.) or anything "prey attentive" that another zombie can see another zombie doing.[11] This is a type of visual signal.

Thus, we now have visual signals to add Zn when doing our calculations. We thus have visual signals and can amend "Axiom C" from Section 1 as follows:

> C) Zombies send out an alert signal when they sight prey, usually in the form of a moan or other more articulate utterance, or, as a visual cue in the form of their actions that show the signaling zombies are "prey attentive."

Let us now look at a few examples of "false signals" and how they might lead to "resonant signals" within a super cell.

Thought Experiment A – False Audio Signal Automata

In this experiment we have a single zombie and what it believes to be a prey alert signal. Suppose a zombie sees a human and gives chase. The human slips into a building and slams a door between himself and the zombie. Inside the building a stereo is on and a human voice is heard singing through the door to the zombie. While the true human continues on through the building and escapes out the other side, the zombie continues to pound on the door believing the human is still trapped inside and just out of reach.

Above is a false audio signal caused by automata. This would constitute one of a near infinite set of possibilities for a false audio signal to cause a zombie to be attracted and adhered to a location.

The zombie would react to that false signal in the same way it would react to a true signal.

Thought Experiment B – False Visual Signal Automata

In this experiment we have a single zombie and what it believes to be a prey alert signal. Suppose a zombie sees a human and gives chase. However, there is no human. Rather, the zombie is attracted to a completely human-looking store window mannequin. The mannequin has been attached to a motorized affair that gives it the appearance of being engaged in human movement/activities. As long as the motor stays on to animate the mannequin and the window remains unbroken, the zombie will attempt to follow its instincts and respond to what is in actuality a false visual signal.[12]

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[11] "Prey attentive" is when a zombie is focused on prey and the body posture/actions it assumes and engages in from that focus.

[12] Or longer, depending on how convinced the zombie is that the now motionless "human" is actually still human and that it's not merely "playing dead" to "fool" the zombie. In any event, this question is properly the field of other necropologists besides the authors. It is a matter of some debate as to how long of an attention span non-actively alerted zombies will have and how long it will stick with a specific prey target if it receives no signals from the target or other zombies. This paper, again, deals more with alert situations than non-alert zombie behavior. We encourage others to speculate and communicate their results.

The zombie would react to that false visual signal in the same way it would react to a true signal arising from true prey or the prey alert of other zombies. This would constitute one of a near infinite set of possibilities for a false visual signal to cause a zombie to be attracted and adhered to a location.

Thought Experiment C - The Glass Box

Let us now examine the Glass Box and see if it can shed any new light on current zombie theory.

The previous experiments dealt with a single zombie being fooled by false signals. What happens if multiple zombies encounter false signals? What if they themselves set up and then propagate false signals?

First, we must imagine that a typical zombie plague has begun and that several hundred thousand humans have been turned. They wander a depopulated country side in search of food….

NOW,

Imagine an impenetrable glass box set in the middle of a large field. The glass box is so strong that no zombie can penetrate it. The glass box has air holes on the top, water pipes underground and all the modern conveniences of life. In addition to the small and large luxuries of life, the box contains a year's supply of food. The box has one human inhabitant.

Now, imagine that a zombie wanders by, and upon seeing the inhabitant inside the box, the zombie rushes over to the walls of the box and begins to pound on it and sets up wailing out a zombie prey alert signal.

The inhabitant of the box smiles and waves to the zombies, secure in his environment.

Now, imagine that several more zombies wander by and they respond to the alert signal sent out by the first zombie. The additional zombies shamble over to the box and also start pounding and wailing. Zn and ZCF are on the rise at this location.

The inhabitant of the box smiles and waves to the zombies, secure in his environment.

Now, imagine that several hundred more zombies wander by and they respond to the original prey alert signal of the first zombie, the chorus of prey alerts given by the second group of zombies and then give off *their own* prey alert signal as they all crowd around the box. Zn and ZCF are both growing pretty wild now!

The inhabitant of the box smiles and waves to the zombies, secure in his environment.

As time goes by, more and more zombies hear the din coming from the area of the box and are drawn to it by ZCF. When they arrive, they add their own teeth gnashing and wailing to the general alert. They are also giving off a heck of a visual signal as they form a writhing and tumultuous mass around the box.

Now, assume several *thousand* zombies arrive. They too hear the prey alert, come running, join the crowd around the box and then contribute their wailing to the din.

At a given point the crowd of zombies would become so thick that newcomers will not be able to see the inhabitant of the box through the crowding zombies. However, they hear the wailing of their fellow zombies, see the huge crowd and they move in to add their own zombie cry to the frenzy.

At a certain point the newly arrived zombies' chorus would be louder en masse than the original observing zombies' alert alone. This is obvious as several hundred second-hand zombie signals would be louder than the few around the box who can actually see the inhabitant.

As the year's supply of food passes, the inhabitant of the box dies.

The zombies closest to the box, those who can peer inside, can now "see" the dead inhabitant.[13] As time wears on they can see him decay and begin to resemble a zombie, he becomes a rotting corpse.

At this point, the astute reader will ask: How can they see him use up his food, die *and then* stick around long enough *to watch him decay*? As there is no longer any actual prey available, why do the zombies not leave when the inhabitant dies?   What happens in the area of the box to cause the zombies to stick around so long that he will decay?

The answer is: it is unlikely that the zombies around the box will ever leave the box until they are destroyed by time, nature or human forces. They will stay there indefinitely, even after the inhabitant dies and is no longer a viable prey source!

To come to terms with this notion, one need only recall that at a certain zombie density, the arriving zombies will not be able to see the human inside the box. The fresh arrivals will overlook that aspect of their adventure and add their own wailing to the din simply because the other zombies are giving them a zombie prey alert! [14]

Thus, at first, as the first few zombies arrive, we have true prey signals being given off (by the human) and transmitted from the first zombies to subsequent zombies. The

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[13] The exact mechanics of zombie vision/eyesight remain unresolved. This is in itself a broad field of inquiry.

[14] Zombies are very trusting of other zombies' prey alert signals. One might even say they have "faith in their fellow zombies."

subsequent zombies, even if they cannot see the human, *will also* transmit prey alert signals to all subsequent zombies and *each other*.

The key moment in understanding the puzzle is when the human dies and/or becomes unrecognizable as prey. The original zombies that were giving first-hand zombie signals from this first-hand observation *will* stop giving their "I actively see prey" alert. *However*, as they are in the middle of a tremendous crowd of zombies who are also giving off a prey alert, they take up *that* signal (the one all around them) as they cannot tell, remember or care that the signal they are receiving is simply an echo, a resonance, of their original prey alert signal.[15]

Keep in mind, every prey alert to a zombie is a valid prey alert.

Thus, once the inhabitant dies, the *original* zombies move into the *same alert state* as the *late arriving zombies.* That is to say, they too do not see any prey, yet they hear an all-encompassing prey alert signal in their general vicinity. They immediately begin to respond to the prey alert signal being given off by the remaining zombies and continue to wail a prey alert signal themselves.

If one assumes a crowd of several thousand zombies, one must realize that the majority of the late-arriving zombies *never* saw any prey, they were held in place by ZCF from an unseen original source.

This bears repeating in the most aggressive style the authors can muster:

MOST OF THE ZOMBIES NEVER SEE THE PREY, NOR DO THEY SEE THE PREY DIE, YET THEY ADD TO THE GENERAL SIGNAL BECAUSE THEY RECEIVE SIGNALS FROM OTHERS.

Again, *every* prey alert to a zombie is a valid prey alert to a zombie.

Now, even with the inhabitant dead, the original zombies that were giving a true prey alert hear others giving a prey alert and begin to take up the relatively false prey alert and repeat it with the same ferocity as the original true prey alert they gave off.

What started as a true signal has become a false signal. A false signal with resonance!

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[15] While zombie linguists are few and far between in necropology, we can safely say that zombies are not masters of complexity in their communication. Their language is not complex, it usually resolves down to "alert = food and food = here I come."

The zombies have become tigers chasing their own tails.[16]

We must now face the fact that Axiom D from section 1 is creating a terrible condition, the zombie black hole:

> D) A zombie otherwise not engaged in either attacking or stalking previously sighted prey will travel towards an alert signal given out by another zombie and will add its own signal to the din created by the first signaling zombie.

Thus to our original list of Axioms in section 1, we must now add a horrific new axiom, G:

> G) A zombie mass of sufficient size may create a resonant alert signal that has no existing true prey alert signal present and continue that signal until and unless zombie attrition eradicates the mass.

We can express resonant signals and their effect on ZCF formulaically as follows:

$$ZCF = RZn \, (Zm_1 * Zm_2 / r^2)$$

Where,

ZCF is the zombie cohesive force between the zombie masses,
RZn is the resonant zombie noise constant,
Zm_1 is the first zombie mass,
Zm_2 is the second zombie mass and
r^2 is the distance between the masses

At this point the astute reader realizes that the glass box, and the zombie hordes attempting to break in, is the genesis of a simple zombie black hole. It goes through the cell stage to the super cell stage and on to zombie black hole.

Super cells become zombie black holes when the super cell stops moving, ignores true signals and has a self-propagating signal. We will see this occurring in multiple locations across the landscape as this process will accelerate as true prey becomes scarce. Black holes can form even in the middle of a field, far away from urban centers.

The only thing that escapes the event horizon of a zombie black hole is signal radiation. Zombies pulled into a black hole cannot escape due to the continuous echoes of alert signals. This resonance overrides any tendency for the zombies to disperse once prey is

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[16] It is important to note at this point that the prey signal need not be a "real" or legitimate signal based on a true sighting by a zombie of true prey to keep a zombie enthralled. Let us face it, zombies are rather stupid, there may indeed be no need for a glass box or even a human inhabitant. This could all begin with an empty building that a single zombie believes contains prey. As long as a prey alert signal attracts zombies and those zombies contribute their wailing, signal resonance will be achieved regardless of the observations or fate of the originating zombie.

captured and eaten (or disappears.) When the resonance becomes so great that it stays fixed on a central radiance point, it might also be possible that the zombies physically collapse into a zombie singularity.[17]

All free-roaming zombies capable of hearing or reacting to a zombie alert signal will eventually be absorbed into a zombie black hole (excepting Zombie Quirks, see section 4 below.)

As stated, zombie black holes have a large self-sustaining alert signal and can outshine in attractiveness any other smaller cell or super cell. Given the right conditions, a black hole might approach millions of members in size and even be visible from space. Given the right conditions, the noise from a black hole might be heard tens, if not hundreds, of miles away and attract any and all zombies still capable of motion towards itself.

Now that we know the bleak future if a zombie black hole should form over one's location, let us turn to a more cheerful thought: the idea of cells and super cells being divided by external forces and weakening (relative to themselves) due to stress-fission.

3. Zombie Cell Stress-Fission

 Zombie cells and super cells are susceptible to Stress-Fission, black holes are not.

Let us start with a simple example of a cell fissioning into smaller cells (or pulled apart entirely if it is only two zombie members in size.)

Let us assume a cell centered on a line along the x-axis and further assume that the prey signal that caused it to cohere has just ended. Now assume that a new prey alert signal comes in from the –x direction outside of the cell and another prey alert signal comes in from the +x direction, also outside of the cell at the same time.

The cell will now have ZCF coming in from two directions; what happens if the prey alert signal in the center ceases and the zombies are pulled in two different directions? In other words, what happens to a cell when it is subject to a surface force acting as a tensile force?

To start we begin with stress, which leads to fission of the cell (assuming the force is "strong" enough.)

Stress on the cell begins as:

$X = ZCF (X)$

Where,

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[17] This refers to a tightly packed necro-mass in the center with zombies pressing in on all sides. Not to be confused with the singular biting zombie at the start of the Big Bite (which is also referred to as a singular zombie / zombie singularity.)

X is the starting point along the x-axis of the cell, and
ZCF is ZCF

Now, with two forces along an axis, we have

$X_1 + X_2$

Where

X_1 = ZCF (X_1), and
X_2 = ZCF (X_2)

This is how the zombie cell begins to deform along the x-axis, where there is no ZCF holding the cell in the center, the deformation will easily lead to fission. At the moment fission is happening inside the zombie cell (or super cell) we must use the following formula:

$\Sigma_{avg} = ZCF_n / A \approx \Sigma$

Where,

Σ is stress,
ZCF_n is total number of ZCF,
A is the cross-section of the cell, and
Σ_{avg} is the average stress

ZCF, here, is distributed across a cross section and one assumes equality of ZCF with the net result of fission along said equilibrium point.

In other words, a zombie cell or super cell will achieve fission if it has external ZCF pulling it apart. Again, however, a zombie black hole provides extreme internal ZCF and cannot be pulled apart by stress-fission. If it is pulled apart, then it was not, by definition, a black hole, rather, it was a super cell.

Interestingly, one may also apply this rather liberally to individual zombies inside a chaos cloud. A zombie, receiving multiple signals is actually being pulled "internally" by stress-fission. He/she will eventually be pulled in multiple directions by such stress forces. A further analysis of the tensors involved inside a chaos cloud and their resemblance to larger cell forces is, alas, beyond the scope of this paper and the authors' current modeling.[18]

4. Zombie Quirks and/or Quirk Zombies

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[18] If anyone would like to take up the "tensor challenge" of modeling all the Zn and ZCF in a cloud, we would love to see the math and results!

Zombie quirks are zombies who can neither see nor hear.[19] This handicap means that they cannot respond to zombie signals and may only roam the countryside.[20] Zombie quirks are those pesky zombies that cannot be lured into forming a cell, super cell or black hole and must be mopped up by human attackers individually and, usually, in unpredictable locations. They are wanderers.

It should be noted that quirks *might* be pulled into a zombie black hole, at least temporarily. Quirks are at least tactile in their environmental sensing, thus, if they wander into a black hole, they might start grabbing other zombies in the zombie mass. Thus, they might be fooled or "alerted" by the zombie mass and its actions into believing prey is nearby or that zombies themselves are prey. One must conjecture that at given enough time and mobility that a quirk would eventually pass through and out of a black hole. Additional research on quirk behavior lies ahead of us.

5. Conclusions

The authors began this paper with a notion that there is a dangerous misconception at the core of current zombie theory. In current thinking, zombies are essentially loners who occasionally appear to hunt in accidental groups. The underlying mechanics of group cohesion were unexamined and the implications of zombie signaling had not been critically assessed. Basically, current thinking falls into a general sense of "if they don't see or hear you, they'll pass by and you can make your escape."   How zombies might group, why they might stay grouped, notions of true and false signals, signal resonance and zombie black holes were all undiscovered country.

One might say that current zombie theory is stuck in a limited notion of our paper's Chaos Cloud, which, as we have demonstrated is merely a beginning. We now know that the Chaos Cloud *is a step* along the way in zombie group strength and *not the entire path*. Some researchers (and popular entertainment) have shown that zombies will group together and act to take down prey in cell-like groups. However, the mechanisms of cell development have never been shown in detail by anyone previously. Certainly nothing like the cell, super cells we have demonstrated as the probable groupings that will occur during a zombie plague has ever been presented.

We hope that the authors have corrected current dangerous notions about what a zombie plague will look like and what will happen to "all those dang zombies" once prey begins to dwindle. At a minimum we believe we have added facts to the discussion that will lead to a correction of the idea that zombies are less predictable than they actually are…

To that end, we have developed the notion of Zombie signaling (Zn) and the resultant Zombie Cohesive Force (ZCF) that comes from that phenomenon.

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[19] For example, a zombie that has had its ears blown off by a sharp-shooter and its eyes were poked out by a sharp stick in the hands of an intrepid housewife/survivor.

[20] They are also called "zombie free radicals" by some researchers.

We believe strongly that Chaos Clouds, Cells, Super Cells and Black Holes are not only possible but probable, due to ZCF. Once a "Big Bite" occurs, if there is sufficient human prey being turned, we believe that a zombie plague will quickly run the gamut of Cloud, Cell, Super Cell and on to Black Hole/s.

We believe that the only serious factors that limit cell growth are Zombie Attrition (Zatr) and Cell Stress-Fission. Thus, now we can see that despite popular notions of fending off a few zombies (or a few hundred) if left unchecked, the zombie plague will go through several stages of zombie massing and may result in many zombie black holes blighting the landscape.

We now know that while urban areas should be avoided, cells can form anywhere. Similarly, super cells can also form anywhere and they, like cells, are mobile and can crawl across the landscape devouring all in its path. Should a super cell stop in a zombie-rich area and a resonant signal develop, one might witness a zombie black hole that numbers into the millions and be visible from space.

It is our sincere hope that this paper serves as a "timely warning" of what we might be facing should the Big Bite occur. The time to eradicate the zombies is as close to the Big Bite as possible. If not, Zn signals should be eliminated as fast as possible while also minimizing one's own actions that might alert any nearby zombies. While these, themselves, are not new strategies, the repercussions of failing to take action are well documented in their novel form in this paper. A black hole awaits those who do not understand it.

The authors believe that without such knowledge, chances of human survival are bleak. However, all hope is not lost! The authors that believe with a bit of planning and some critical thinking, one might be able to use ZCF to destroy zombies, turning it back upon them. Again, of course, the first strategy is to stop the signal from propagating ASAP, before it can reach self-propagation. Stanch cell creation, stanch super cell creation and, of course, avoid any area that has a black hole in it.

ZCF *might* be used to create a super cell and allow it to form into at a black hole at a kill spot. This formation could possibly be achieved through "resonant signal generators" being placed at immobilizing areas like natural obstacles (i.e., the Grand Canyon) or where the military and/or civilian militias could ambush and eradicate zombies. That process would take time and one would still have to fear quirks even as the main zombies groups were ensnared by their own nature.

The work has just begun on strategies to employ ZCF against the zombies. The authors are certain that many, many plans could be developed that employ it to human's advantage. At the very least, all humans will want to avoid being trapped in a "Glass Box."

We hope that at the least we have given humans food for thought and that we have also

taken "food for no-thought" from the mouths of the zombie damned.

Lastly, a plea…

Due to the immature and recent birth of Necropology as a field, the authors do not suggest that the theory, rules and results above are the final word. Rather, we invite expanded explanations, hypotheses and opinions about zombies and zombie physics – including those that may run directly counter to our own. We are especially appreciative of the work of esteemed biologists and other "*Lifies*" when it comes to insights on pandemics and epidemics and we desire to hear from them.

Necropologists around the world are hard at work on bite mechanics, viral transmission, longevity and endurance studies of zombie necromass, and even the possible affects of global warming on zombie populations. If you have even the slightest interest in zombies, please consider yourself a necropologist and GET TO WORK!

We implore you all to consider adding to the body of knowledge that will help brace us all against the inevitable coming zombie plague!

Acknowledgements

II. Addendum: Twitter Zombie Experiment

We will be attempting to create a zombie black hole in the social media universe.

The authors are conducting an open-source experiment utilizing social media. We will be testing a hypothesis about signals, signal resonance and we will be attempting to create a virtual zombie black hole on Twitter (and other social-media outlets as they become available). In order to not taint the results we cannot reveal specific details of what we are seeking in our observations and our testing procedures. However, it *is* safe to say that we will be attempting to establish a mass of "Twitter Zombies" and testing the Zombie Cohesive Force through various and arcane metrics.

Become a volunteer Twitter Zombie with us today. We will be having some fun along the way to the black hole, and doing some general musing over all things zombies.
You may join the experiment by either "Tweeting" with us at twitter.com/necropology or if you're already on Twitter, we're @necropology.

Please, if you have anything you would like to add to the debate you now know how to find us!