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1 **Short communication**

2 **Title:** Cleaved CD95L perturbs *in vitro* macrophages responses to *Toxoplasma gondii*

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13

14

15 **Abstract**

16 *Toxoplasma gondii* infects approximately 1-2 billion people, and manipulation of the  
17 macrophage response is critical to host and parasite survival. A cleaved (cl)-CD95L form can  
18 promote cellular migration and we have previously shown that cl-CD95L aggravates  
19 inflammation and pathology in systemic lupus erythematosus (SLE). Findings have shown  
20 that CD95L is upregulated during human infection, therefore we examined the effect of cl-  
21 CD95L on the macrophage response to *T. gondii*. . We find that cl-CD95L promotes parasite  
22 replication in macrophages, associated with increased arginase-1 levels, mediated by signal  
23 transducer and activator of transcription (STAT)6. Inhibition of both arginase-1 and STAT6  
24 reversed the effects of cl-CD95L. Phospho-kinase array showed that cl-CD95L alters Janus  
25 Kinases (JAK)/STAT, mammalian target of rapamycin (mTOR), and Src kinase signals. By  
26 triggering changes in JAK/STAT cl-CD95L may limit anti-parasite effectors.

27 **Keywords:** *Toxoplasma gondii*; macrophage; CD95L; FasL; JAK/STAT; arginase; cleaved CD95L

28

29

## 30 1. Introduction.

31 *Toxoplasma gondii* is an obligate intracellular parasite capable of causing significant disease  
32 in both human and animal hosts. *T. gondii* has the ability to infect multiple cell types but  
33 preferentially infects monocytes or dendritic cells (DCs). Within these cells *T. gondii* is  
34 effectively able to control the host cell niche. Studies have demonstrated that parasite  
35 secreted effectors alter macrophage functions and their regulating signalling mechanisms  
36 [1]. Indeed, multiple effectors target the JAK-STAT cascade and confer virulence in  
37 recombinant avirulent strains of parasite [2]. This is a two-sided process, host priming of the  
38 macrophage is key to effective parasite control and incorrect priming, resulting in arginase-1  
39 producing macrophage, cannot restrain parasite replication [3].

40 The CD95-CD95L (also known as Fas-FasL, respectively) interaction is key to controlling  
41 intracellular parasites via induction of cellular apoptosis [4]. Indeed, appropriate CD95  
42 signalling post-infection is thought to control immunopathology [5]. Studies [6] have shown  
43 that *T. gondii* can inhibit CD95 mediated killing by impairing the correct functioning of  
44 caspase 8. Recently, CD95L has been shown to undergo a metalloprotease-mediated  
45 cleavage event leading to a soluble, cl-CD95L that drives cellular migration rather than  
46 death [4]. Additionally, we have recently shown that cl-CD95L causes exacerbated pathology  
47 during the onset of murine lupus due to increased cellular infiltration within inflamed tissues  
48 [7]. A previous survey of pregnant human toxoplasmosis patients had shown that this form  
49 of CD95L increased during chronic infection [8] and *in vitro* infection with *T. gondii* RH  
50 induced high levels of soluble cl-CD95L in both macrophages and trophoblast cells [9].

51 Given these findings we sought to directly assess the effect of soluble cl-CD95L on the  
52 outcome of macrophage infection with *T. gondii*. We report that cl-CD95L leads to increased

53 parasite replication partially dependent on changes in IL-6 and arginase-1 levels.  
54 Interestingly, these opposing mechanisms may be explained by the finding that cl-CD95L  
55 reprograms macrophages to acquire a Myeloid-Derived Suppressor Cell (MDSC)-like  
56 phenotype.

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## 58 2. Methods

### 59 2.1 Parasite Culture.

60 Host VERO cells were cultured in DMEM supplemented with 5% fetal bovine serum (FBS,  
61 F4135 Sigma Aldrich), penicillin-streptomycin (10,000 U penicillin & 100 mg/ml streptomycin  
62 (Sigma Aldrich) at 5% CO<sub>2</sub> at 37°C in 25 cm<sup>2</sup> flasks until cells were 80% confluent. The RH  
63 strain of *T. gondii* was used throughout the work. Parasites were propagated as tachyzoites  
64 by serial passage in VERO cells. For the purification of *T. gondii* tachyzoites, infected host  
65 VERO cells were dislodged from culture flasks by scrapping with a single-use rubber cell  
66 scraper. Dislodged cells were passed, through a sterile blunt-ended needle. Lysed cells and  
67 isolated parasites were centrifuged at 2,000 rpm for 10 minutes at room temperature (RT).  
68 Parasites were resuspended in 5 mL 1X D-PBS and this solution was added to a PD-10  
69 column, columns were then washed with 5 mL 1X D-PBS. The number of parasites recovered  
70 was counted in 10 µL of parasite solution. Finally, the parasites were centrifuged for 10  
71 minutes at 2,000 rpm, supernatant removed and resuspended in complete DMEM.

### 72 2.2 Bone marrow-derived macrophages (BMDM).

73 Bone marrow-derived macrophages were obtained from healthy wild-type C57Bl/6 mice  
74 aged between 8-16 weeks. Animals were culled by standard schedule 1 procedures of  
75 exposure to rising concentrations of CO<sub>2</sub>. Immediately afterwards hind femurs were  
76 removed and placed into sterile D-PBS for transport to the laboratory. Excess fat, muscle,  
77 and skin were removed. Thereafter, the bone marrow was flushed from the femur by  
78 repeated injecting, using a 2 mL syringe and a 25-gauge needle, of the femur with complete  
79 media. Cells were passed through a 70 µm cell strainer and centrifuged for 10 minutes at

80 1,500 rpm. Bone marrow cells were seeded at  $2 \times 10^6$ /mL in a 6 mL petri dish with the  
81 addition of 20 ng/mL of M-CSF (Recombinant Murine M-CSF, PeproTech). Every two days the  
82 media and M-CSF was replenished until cells were harvested on day 7. Thereafter  
83 macrophages were seeded in 96 well flat-bottomed plates (Greiner Bio-One) at  $2 \times 10^4$ /well.  
84 In some experiments chemical inhibitors or antibodies were added to cultures prior to  
85 infection as follows; anti-mouse IL-6 (BioXCell Clone MP5-20F3) was used at 120 ng/mL; to  
86 inhibit Arginase,  $N^{\omega}$ -hydroxy-nor-Arginine (nor-NOHA) (Sigma) was used at 5 mM; to inhibit  
87 cl-CD95L, mFas-Fc Chimera (R&D Systems Cat No. 435-FA) was added at 200 ng/mL; and to  
88 inhibit STAT6, the compound AS1517499 (Sigma) was used at 0.2 mg/mL.

89

### 90 *2.3 Percentage monolayer destruction and free parasite counts*

91 VERO cells or BMDM were seeded into 24 well plates at  $2.5 \times 10^4$ /well and incubated for 24  
92 hours. Thereafter, cells were stimulated with cl-CD95L at indicated doses and 24 hours later  
93 cells were infected with *T. gondii* at  $1 \times 10^5$ /well (MOI 4). After 3 hours the medium was  
94 changed to remove free extracellular parasites and replaced with fresh media. Thereafter,  
95 cells were incubated for 72 hours. After 72 hours post-infection the percentage of the VERO  
96 monolayer that has been destroyed was estimated using an Olympus BH2 microscope at X10  
97 magnification, using a previously described method [10]. In brief, a counting grid was  
98 overlaid onto images and consistent squares were counted across images. Destruction was  
99 recorded were 50% of cells within a grid square no longer had an intact membrane. An  
100 aliquot of supernatant was used to determine the extracellular parasite load.

### 101 *2.4 ATP and Cytokine Detection*

102 Supernatants were collected from BMDM cultures and used for CellTiter-Glo assays for the  
103 detection of ATP. 100  $\mu$ L of each sample and media controls, as background controls, were  
104 added to a 96-well opaque plate. The plate was then left at RT for 30 minutes to equilibrate.  
105 Thereafter, 100  $\mu$ L of CellTiter-Glo<sup>®</sup> Reagent was added to each well. The contents were then  
106 mixed for 2 minutes on an orbital shaker, followed by a 10 minutes incubation at RT.  
107 Luminescence was then recorded using a luminometer. Cytokine ELISAs for IL-6 and IL-1 $\beta$   
108 were conducted using commercially available kits from Invitrogen (Cat no. 88-7064-88, 88-  
109 7013, respectively).

#### 110 *2.5 Arginase assay.*

111 Cell lysates were prepared in Triton X-100. 50  $\mu$ L of 10 mM MnCl<sub>2</sub>/50 mM Tris-HCl buffer (pH  
112 7.5) and 50  $\mu$ L of lysate were mixed and incubated for 10 minutes at 55°C for enzyme  
113 activation. 50  $\mu$ L of 0.5 M L-arginine substrate (pH 9.7) was added to the activated lysate  
114 and incubated for 1 hour at 37°C. To stop the reaction the acid-stop solution that was  
115 comprised of H<sub>2</sub>SO<sub>4</sub> (96%), H<sub>3</sub>PO<sub>4</sub> (85%), and H<sub>2</sub>O in a ratio of 1:3:7 was added to the  
116 samples. Finally, 9% isonitrosopriophenone was added to develop colour. The sample was  
117 then heated to 103°C for 45 minutes and allowed to cool in darkness for another 10 minutes.  
118 200  $\mu$ L aliquots are then added to a 96 well ELISA plate and absorbance measured at 540  
119 nm.

#### 120 *2.6 BMDM Phospho-Kinase Array*

121 To determine a global signalling profile a Phospho-Kinase Array Proteome Profiler was used  
122 (R&D Systems, Cat No. ARY003B) BMDM were either left unstimulated or stimulated with  
123 100 ng/mL of cl-CD95L for 24 hours, after which macrophages were rinsed with D-PBS.



124 Macrophages were then solubilised at  $1 \times 10^7$  cells/mL in Lysis Buffer 6 (R&D systems).  
125 Samples were pipetted up and down in order to resuspend macrophages and incubated for  
126 30 minutes at 2-8°C. Samples were then microcentrifuged and the supernatant transferred  
127 to an Eppendorf tube. Membranes were placed in the wells of an 8-Well Multi-dish and filled  
128 with 1.0 mL of Assay Buffer 1, which served as a blocking buffer. The plate was incubated on  
129 a rocking platform shaker for 1 hour. Membranes were then washed in 20 mL of wash  
130 buffer. After which, 1.0 mL of prepared samples were added to both parts A and B of each  
131 membrane. The plate was then incubated on a rocking platform shaker overnight at 2-8°C.  
132 Then 1.0 mL of reconstituted Detection Antibody Cocktail in Assay Buffer was added to each  
133 well and incubated with shaking for 1 hour at RT. After, 1.0 mL of diluted Steptavidin-HRP in  
134 Array Buffer 2/3 was added to each well of the plate and incubated with shaking for 30  
135 minutes at RT. Membranes were then washed. After washing, 1.0 mL of Chemi-Reagent Mix  
136 was added to each membrane and incubated for 1 minute. After incubation, excess Chemi-  
137 Reagent Mix was removed from each membrane. Membranes were imaged using a  
138 ChemiDoc. Pixel Density was measured using ImageJ software. The pixel density was  
139 normalised to total protein concentration in each lysate as determined by BCA assay.

140

## 141 *2.7 Statistics*

142 Raw data was collected on Microsoft Excel workbooks. All data analysis was conducted using  
143 Prism 7 (GraphPad). P values of  $< 0.05$  were taken as significant, the details of individual  
144 tests are reported in the figure legends.

145

### 146 3. Results

#### 147 3.1 Cleaved-CD95L alters *T. gondii* replication within host cells.

148 We initially tested the effect of pre-treatment of the VERO cell line with cl-CD95L prior to  
149 infection with *T. gondii*. Infection with *T. gondii* alone increases cellular destruction from 2%  
150 in uninfected/unstimulated to 14% in infected/unstimulated (Fig.1A;  $P < 0.01$ ). VERO cells  
151 were stimulated with 100 ng/mL of cl-CD95L and then infected with *T. gondii*, giving rise to  
152 26% cellular destruction that is statistically significant compared with stimulated but  
153 uninfected cells (Fig. 1A;  $P < 0.01$ ). The difference in cellular destruction between infected  
154 cultures when cl-CD95L was present was also statistically significantly different,  $P < 0.01$  (Fig.  
155 1A). Host cell destruction is often an indicator of cell egress. The number of parasites in the  
156 supernatant was determined after 48 hours of infection by manual counting. Figure 1B  
157 demonstrates that a significant increase in parasite replication occurs after stimulation with  
158 cl-CD95L ( $12 \times 10^4$ /mL parasites) when compared to unstimulated VERO cells ( $9 \times 10^4$ /mL  
159 parasites;  $P$  value  $< 0.05$ ). Having demonstrated that the increase in monolayer destruction  
160 above might be caused by the increase in *T. gondii* load following cl-CD95L stimulation we  
161 sought to determine if cl-CD95L was causing these effects by decreasing cell viability. We  
162 assessed extracellular ATP in supernatants, the results show that before infection, as  
163 expected, there are high levels of cell viability as indicated by high levels of ATP (Fig.1C). In  
164 comparison, after infection with *T. gondii* the levels of cell viability, in both unstimulated and  
165 stimulated conditions decrease ( $P$  value  $< 0.001$ ).

166 To ensure our results were representative of primary host cells, we assessed the effect of cl-  
167 CD95L in murine macrophages. Bone marrow derived macrophages (BMDMs) were matured  
168 from bone marrow in the presence of M-CSF for 7 days prior to collection and further use.

169 We investigated the impact of stimulation with cl-CD95L on parasite replication in BMDM by  
170 performing parasite counts after 48 hours of infection. As shown Figure 1D, a significant  
171 increase in parasite counts occur after BMDM cultures have been stimulated with cl-CD95L  
172 when compared to unstimulated cultures (P value <0.05). Additionally, we demonstrated  
173 that the effects observed were directly due to cl-CD95L by use of a Fas-Fc fusion protein to  
174 compete with cl-CD95L [7]. Figure 1E demonstrates that in the presence of the decoy  
175 receptor CD95-Fc, parasite replication levels were not significantly different from untreated  
176 infected controls.

177

### 178 3.2 cl-CD95L alters arginase-1 and IL-6 levels during *T. gondii* infection.

179 To determine if the increase in parasite load, mediated by cl-CD95L, paralleled changes in  
180 the BMDM response to infection we measured IL-6 in the supernatants of infected BMDMs  
181 in presence or absence of cl-CD95L. Figure 2A clearly demonstrates that cl-CD95L treatment  
182 alone did not drive the increase in IL-6 alone but did elicit an increase in IL-6 in combination  
183 with *T. gondii* driven cytokine expression. IL-6 production driven in this manner was not anti-  
184 parasitic. Neutralisation of IL-6 in the presence or absence of cl-CD95L caused a decrease in  
185 parasite numbers (Fig.2B). As previously demonstrated cl-CD95L caused an increase in  
186 parasite number but this was reversed in the presence of anti-IL-6 (Fig.2B).

187 This led us to speculate that a second host factor, triggered by cl-CD95L, was responsible for  
188 the effects on parasite load in BMDMs. To test this, we first assayed cl-CD95L treated and  
189 infected BMDMs for arginase and found elevated levels following *T. gondii* infection but  
190 treatment with cl-CD95L resulted in a further increase in these levels (Fig.2D). Indeed, the  
191 effects of cl-CD95L induced increased arginase could be reversed with the application of the

192 inhibitor nor-NOHA. Simultaneous application of both cl-CD95L and nor-NOHA resulted in  
193 significant decrease in parasite levels compared with cl-CD95L treatment only (Fig.2D); levels  
194 of parasite obtained in cl-CD95L/nor-NOHA cultures were similar to those in non-treated  
195 infected controls (Fig.2D). Interestingly, we found arginase-1 and IL-6 to be mechanistically  
196 linked as nor-NOHA inhibition of arginase also caused a decrease in IL-6 levels during cl-  
197 CD95L stimulation and infection (Supplementary Fig.1). STAT6 is a major transcriptional  
198 regulatory of alternative activation of macrophages during helminth infection [11-13]. It has  
199 been shown to drive the expression of arginase-1 during both cytokine and pathogen  
200 stimulation. We employed chemical inhibition of STAT6 to determine if it was directing cl-  
201 CD95L mediated arginase. During stimulation alone, cl-CD95L caused an increase in arginase-  
202 1 activity (Fig.2F) but the application of a STAT6 inhibitor AS157499 caused a decrease in  
203 these levels. Importantly following infection, we found that the synergistic increase in  
204 arginase was also ablated (Fig.2F). Phenotypically inhibition of STAT6 gave rise to a lower  
205 number of parasites but only after the application of cl-CD95L (Fig.2G;  $P < 0.01$ ); suggesting  
206 that cl-CD95L drives a STAT6 response, upregulating arginase, that mediates reduced  
207 parasite killing. Our data above would indicate that IL-6 when induced by cl-CD95L is not  
208 protective; to test if cl-CD95L:STAT6 signalling is involving in this we assayed supernatants  
209 for IL-6 levels. We show that cl-CD95L drives a synergistic increase in IL-6 following *T. gondii*  
210 infection ( $P < 0.05$ ) and importantly STAT6 inhibition in this setting causes a complete  
211 removal of IL-6 (Figure 2H).

### 212 3.3 cl-CD95L modifies the macrophage signalling landscape.

213 To address whether there was a pattern of cell signalling induced by cl-CD95L that could  
214 underlie the effect on increased parasite replication, and associated immune responses in

215 BMDMs, we performed a Phospho-kinase profiler array on cl-CD95L stimulated BMDMs.  
216 Exploring the cellular environment preceding infection was important and thus our  
217 experimental design relied upon prior stimulation with cl-CD95L, as we had shown above  
218 that this resulted in a cellular environment more permissive to parasite replication. 38 of 43  
219 kinases were found to be expressed under both stimulated and unstimulated conditions.  
220 Using a Log<sub>2</sub> fold change we identified 23 kinases upregulated in stimulated vs unstimulated  
221 BMDMs (Fig.3A). These were subject to STRING (V11.0) analysis to identify potential  
222 interactions using a database search. The top five Biological Processes and Reactomes are  
223 depicted in Figure 3B. Not unexpectedly, 3 GO terms identified map to  
224 phosphorylation/signal transduction and one to apoptotic processes. Cytokine signalling and  
225 immune system responses were identified within the Reactome analysis.

226 A network was constructed from the log<sub>2</sub> fold upregulated proteins and three nodes are  
227 apparent – one involving STATs, one centred on mTOR, and a third involving the Src family  
228 (Yes, Fyn, Lck). Multiple members of these nodes, including Yes/Fyn/Lck, have significant  
229 overlap with factors previously identified as being elicited by cl-CD95L [4, 7]. STAT2/3/5A  
230 were identified in a node; STAT2 was previously shown to be negatively regulation immune  
231 protection in *T. gondii* infection, as STAT2<sup>-/-</sup> macrophages more effectively control their  
232 parasite load [14]; while STAT3 mediates susceptibility to *T. gondii* [15, 16]; and STAT5 has  
233 been implicated, albeit weakly, with increased parasite susceptibility [17].

234 The node centred on mTOR may indicate an MDSC-like response to cl-CD95L stimulation. A  
235 role for MDSCs, and similar cells, have been subject to increasing scrutiny in the context of  
236 parasite immunity [18]. Given the heterogeneous nature of their surface marker profile [18],  
237 they may have potentially been incorporated into analysis of Gr1<sup>+</sup> monocyte populations in

238 prior *T. gondii* studies [19-22] as many of these Gr1<sup>+</sup> monocytes were also CD11b<sup>+</sup>. Indeed a  
239 population corresponding to these cells was shown to exert both an anti-inflammatory  
240 effect during infection and immune hyporesponsiveness during acute *T. gondii* infection  
241 [22].

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#### 245 4. Discussion:

246 Increased levels of soluble CD95L have been found in both human toxoplasmosis and murine  
247 macrophage infection. Given its potential effects outside of triggering cell death we  
248 examined the effects of cl-CD95L on macrophage infection. Our findings lead us to conclude  
249 that exposure of host cells to cl-CD95L leads to increased *T. gondii* replication and a parallel  
250 rise in host cell destruction. Furthermore, this cell destruction is dependent on parasite  
251 replication but not CD95L apoptotic effects as noted by our ATP findings. We determined  
252 that IL-6 was also upregulated following cl-CD95L stimulated and *T. gondii* infection but this  
253 was not protective as indicated by neutralising antibody. This finding is in line with previous  
254 studies which also detail a role for IL-6 in promoting parasite intracellular replication [23]  
255 conflicting with the protective role also assigned to IL-6 [24]. This contradictory nature of the  
256 resulting macrophage population we obtained following cl-CD95L stimulation and *T. gondii*  
257 infection reflects a previous finding that duality in the macrophage population can exist.  
258 Arginase-1 has been widely reported to negatively impact upon immunity to intracellular  
259 parasites [3] and this is known to arise from a key role in driving alternative activation of  
260 macrophages[25]. Yap and colleagues have described a both classically and alternatively  
261 activated macrophages existing within the same pool of cells following *T. gondii* infection  
262 [26].

263 Combined, the data would suggest cl-CD95L drives STAT6 mediated expression of arginase-1  
264 and IL-6; these factors may synergise with *T. gondii* infection to remove the protective  
265 effects of IL-6 and increase the susceptibility of host cells in an arginase-dependent fashion.  
266 This is consistent with prior reports of IL-6 acting to enhance alternative activation of  
267 macrophages in a STAT3 dependent fashion [27]. Importantly, the autocrine/paracrine

268 induction of arginase-1 by IL-6, via STAT3, has also been shown during Mycobacteria  
269 infection of macrophages [28]. Our Phospho-kinase array data revealed that STAT6 was  
270 only one of multiple STAT members changed by cl-CD95L. Thus, here we show that the  
271 actions of cl-CD95L in promoting parasite replication stem from STAT6 they may, at least  
272 partially, from wider STAT signalling. Myeloid-derived suppressor cells have been linked to  
273 both suppressing but also promoting inflammation in a variety of setting including systemic  
274 lupus erythematosus (SLE) [29]; in this setting MDSCs expressing arginase-1 promoted Th17-  
275 mediated kidney damage. This endstage pathology overlaps with our previous finding that  
276 cl-CD95L drives selective recruitment of Th17 cells into tissues including in a murine model  
277 of SLE [7]. A potential outcome of cl-CD95L stimulation of macrophages could be the  
278 induction of an MDSC-like phenotype, independent of parasite infection. This is in part  
279 supported by the finding that mTOR is upregulated as are a number of other kinases  
280 associated with the MDSC phenotype. Our findings point to the need to closely examine the  
281 role of cl-CD95L during *T. gondii* pathogenesis *in vivo* and to define the role it plays in  
282 eliciting MDSCs. Specifically, does cl-CD95L elicit differentiation and trafficking of MDSCs and  
283 what role do these cells play *in vivo*.

284

285 **Conflict of Interest:** RJF and PL are applicants on a patent surrounding the use of CD95  
286 therapeutics.

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290



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292

293

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370 **Figure Legends:**

371 **Figure 1: Cleaved-CD95L alters *T. gondii* replication within host cells. (A)** VERO cells were  
372 either stimulated with doses of cl-CD95L as indicated. After 24 hours the cells were then  
373 infected with *T. gondii* at a MOI of 5 or left uninfected. After a further 48 hours post  
374 infection the percentage of monolayer was estimated for each group by examination under  
375 a light microscope. **(B)** VERO cells were either stimulated with 100ng/mL of cl-CD95L or left  
376 unstimulated. After 24 hours the cells were then infected with *T. gondii* at a MOI of 5 or left  
377 uninfected. After a further 48 hours post infection the parasite number was determined. **(C)**  
378 Supernatants from the above experiment were tested for ATP using Cell Titer-Glo. **(D)** Bone  
379 Marrow Derived Macrophages (BMDM) were either stimulated as in B). After 24 hours the  
380 BMDM ( $10^5$ ) were then infected and parasite counts as in B). **(E)** As in D) but in the presence  
381 of Fas-Fc chimera (200ng/mL) or control antibody while undergoing cl-CD95L stimulation. All  
382 culture conditions were in triplicate and mean  $\pm$ SD is shown with between 4-6 mice per  
383 experiment. With experiments repeated independently 6 times in A) or 5 times in B)-E).  
384 Data in (A), (C), and (E) were analysed by 2-way ANOVA and data in (B) and (D) by Unpaired  
385 T-tests; \* $P < 0.05$ , \*\* $P < 0.01$ , and \*\*\* $P < 0.0001$ .

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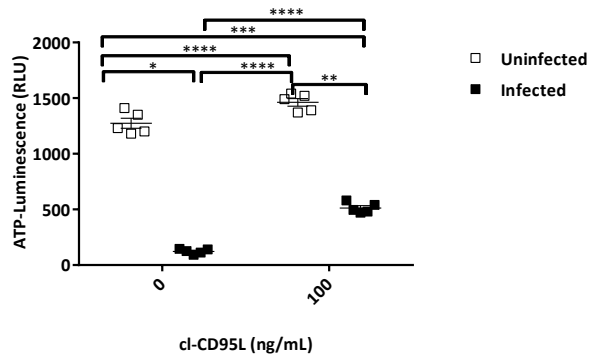
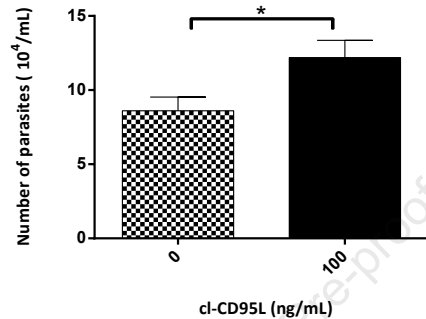
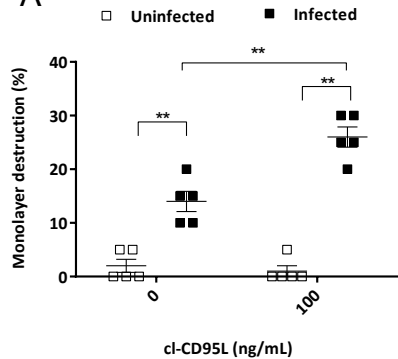
387 **Figure 2: cl-CD95L alters arginase-1 and IL-6 levels during *T. gondii* infection. A)** BMDM ( $10^5$   
388 per well) were stimulated using indicated doses of cl-CD95L. After 24 hours the BMDM were  
389 then infected with *T. gondii* at a MOI of 5 or left uninfected. After a further 48 hours  
390 supernatants were assayed for IL -6 by ELISA. **B) – H)** BMDMs were treated with cl-CD95L at  
391 100ng/mL or 0ng/mL control prior to infection with *T. gondii* at MOI 5. **B)** The addition of  
392 anti-IL-6 (120ng/mL) or control IgG was monitored for an effect on parasite counts as

393 performed in Figure 1. **C)** Arginase activity was measured 48hrs after infection cell lysates; **D)**  
394 Inhibition of arginase was performed by addition of nor-NOHA (5mM) prior to measuring  
395 parasite load; **E)** Matched cell lysates from B) were used to measure arginase activity after  
396 anti-IL-6 treatment. STAT6 was inhibited (As1517499 – 0.2mg/mL) prior to infection and  
397 during stimulation with cl-CD95L thereafter **F)** arginase activity was measured in cell lysates,  
398 **G)** parasite numbers and **H)** IL-6 were measured in the supernatants. Treatments were  
399 performed in triplicate and mean  $\pm$ SD is shown with 4-6 mice per experiment. Each  
400 experiment was repeats 5 times independently. Data was analysed in GraphPad Prism by 2-  
401 way ANOVA where \*P<0.05, \*\*P<0.01, \*\*\*P<0.001, \*\*\*\*P<0.0001.

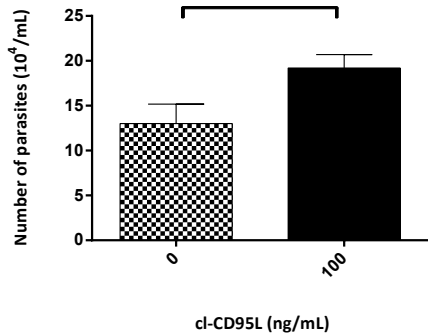
402 **Figure 3: cl-CD95L modifies the macrophage signalling landscape.** BMDM were treated with  
403 100ng/mL of cl-CD95L for 24hrs prior to preparation for use in the Phospho-Kinase array  
404 (R&D Systems). Pixel density captured in ImageJ was normalised to total protein levels. **A)**  
405 Thereafter the  $\text{Log}_2$  fold change in cl-CD95L stimulated vs unstimulated was calculated. The  
406 blue dotted line indicates a  $\text{Log}_2$  fold change while the red dotted line indicates a 2- $\text{Log}_2$  fold  
407 change in expression levels. The 23 proteins with a  $\text{Log}_2^2$  fold difference were then processed  
408 in STRING V11.0 (string-db.org) program to identify potential interaction networks. B) The  
409 top 5 biological processes and reactome pathways are identified presented. C) The potential  
410 interaction network generated is presented, based upon known interactions taken from  
411 InAct. The nature of the interaction is dictated as follows; lines with an arrowhead indicates  
412 a positive interaction, lines with a rounded end indicate unknown interaction, lines with a  
413 flat end indicate a negative end. Results shown are means from 2 independent biological  
414 replicates for each treatment.

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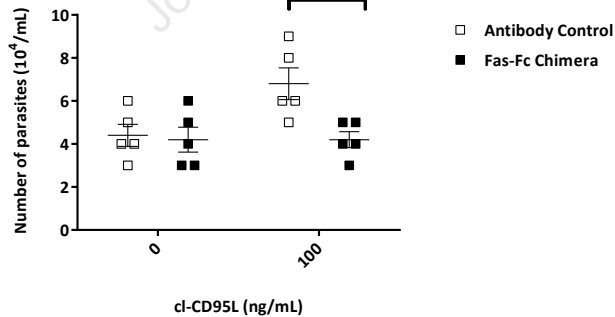
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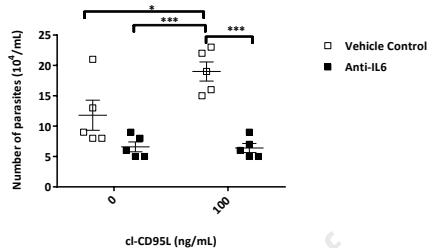
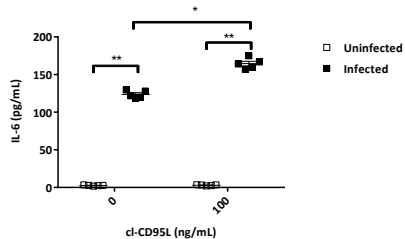
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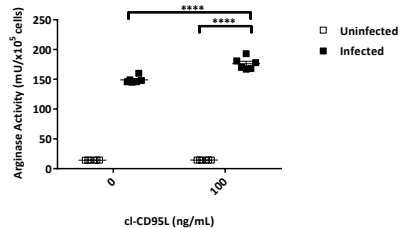
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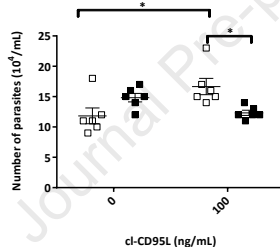
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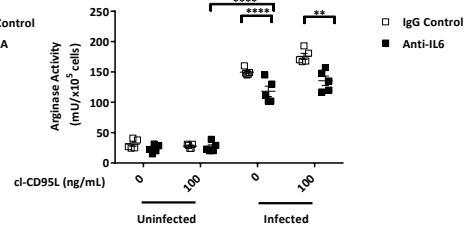
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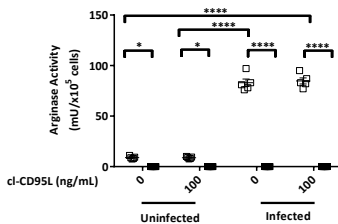
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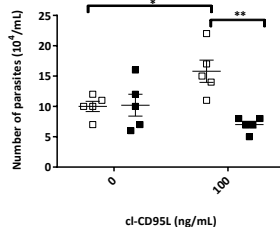
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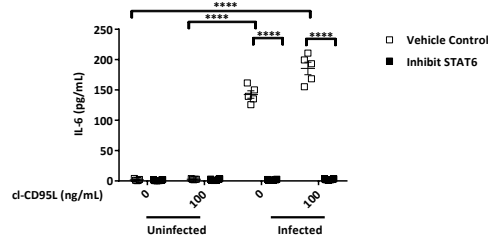
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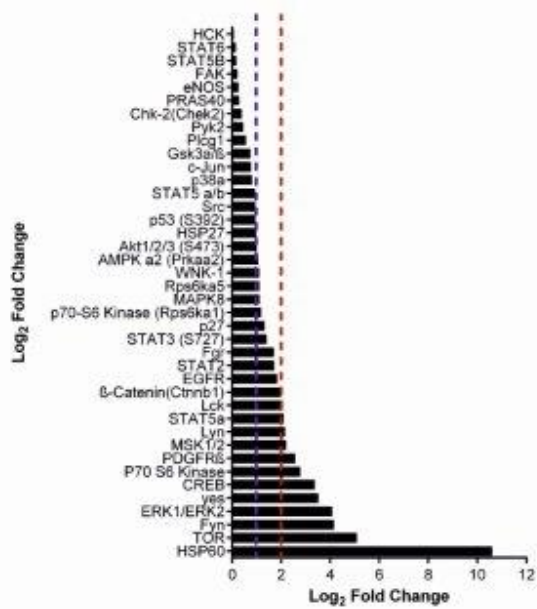
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H



A



B

Biological Processes (GO)		
GO-term	Description	Count in network
GO:0007165	signal transduction	40 of 3594
GO:0006468	protein phosphorylation	28 of 793
GO:0042981	regulation of apoptotic process	32 of 1476
GO:0016310	phosphorylation	29 of 1034
GO:0071310	cellular response to organic substance	33 of 1858

Reactome Pathways		
Pathway	Description	Count in network
MMU-9006934	Signaling by Receptor Tyrosine Kinases	24 of 360
MMU-449147	Signaling by Interleukins	17 of 262
MMU-1280215	Cytokine Signaling in Immune system	18 of 357
MMU-168256	Immune System	26 of 1523
MMU-162582	Signal Transduction	30 of 2430

C

