Modelling Vesicular Stomatitis Virus infection fronts: the key role of the delay time

Daniel R. Amor and Joaquim Fort

CONCLUSIONS

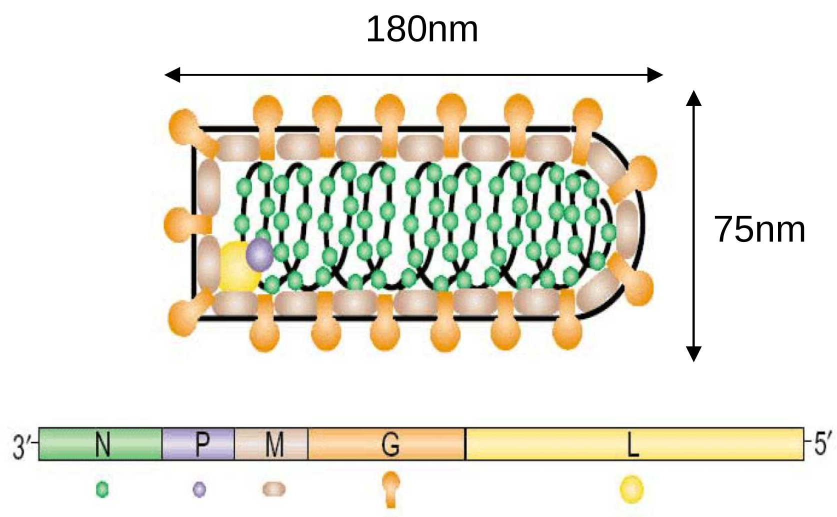
- Time elapsed between viral adsorption and cell lysis is critically important when modelling infection front speeds.

- Front speed decreases with increasing values of the delay time .

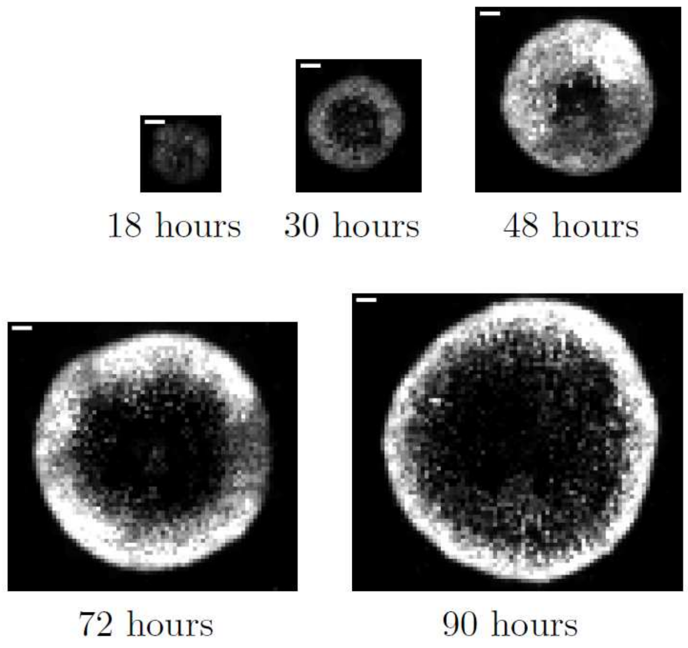
- Few adjusted parameters = Good Biomathematical Model

  Our model uses only two non-measured parameters which do not affect our main conclusions.

Vesicular Stomatitis Virus



- Rhabdoviridae (rabies virus).
- ARN virus (HIV, hepatitis, influenza..).
- High mutation rate (adaptation, resistance).

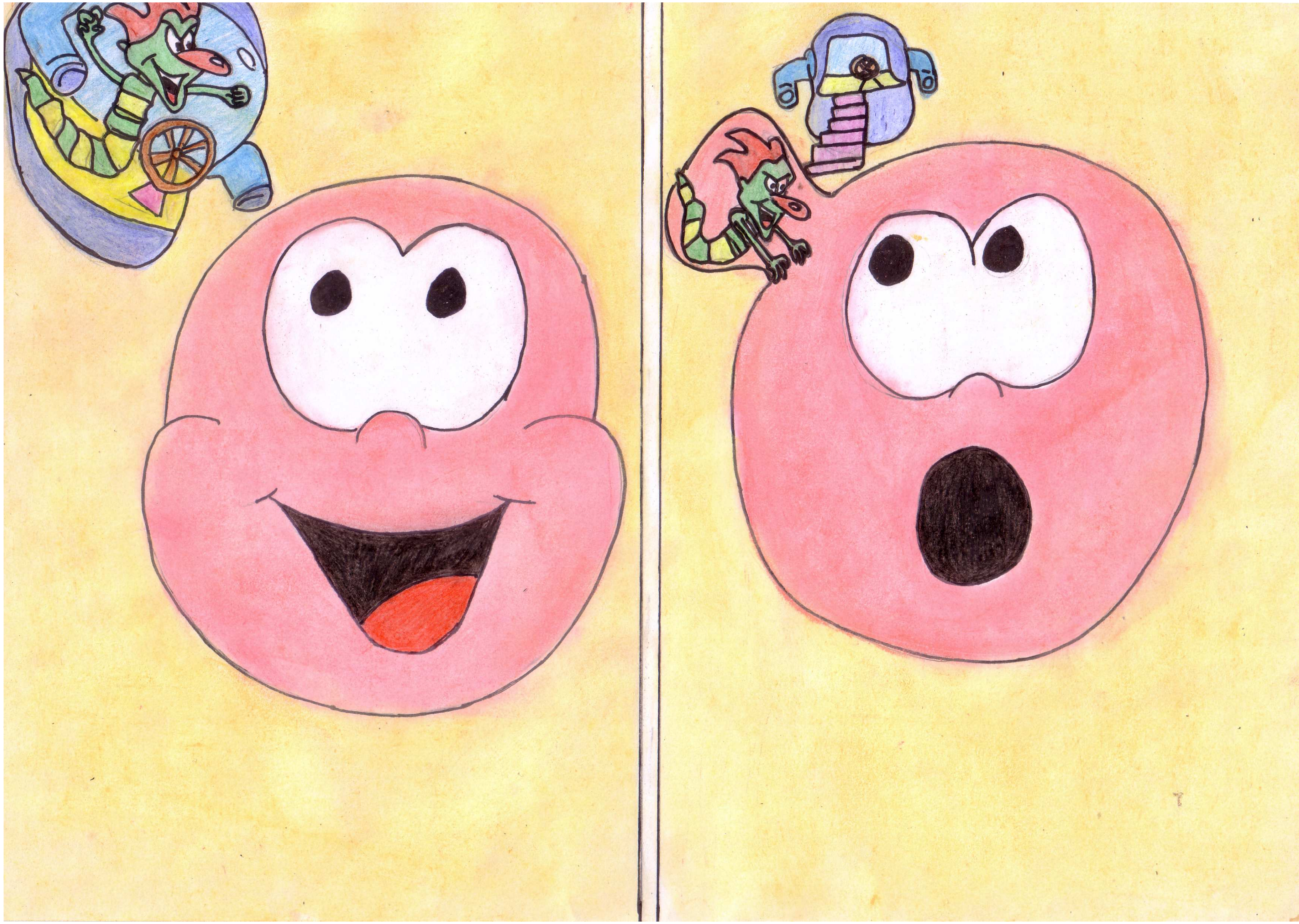


- **Previous model: Haseltine et al., Bull. Math. Biol. (2008).**

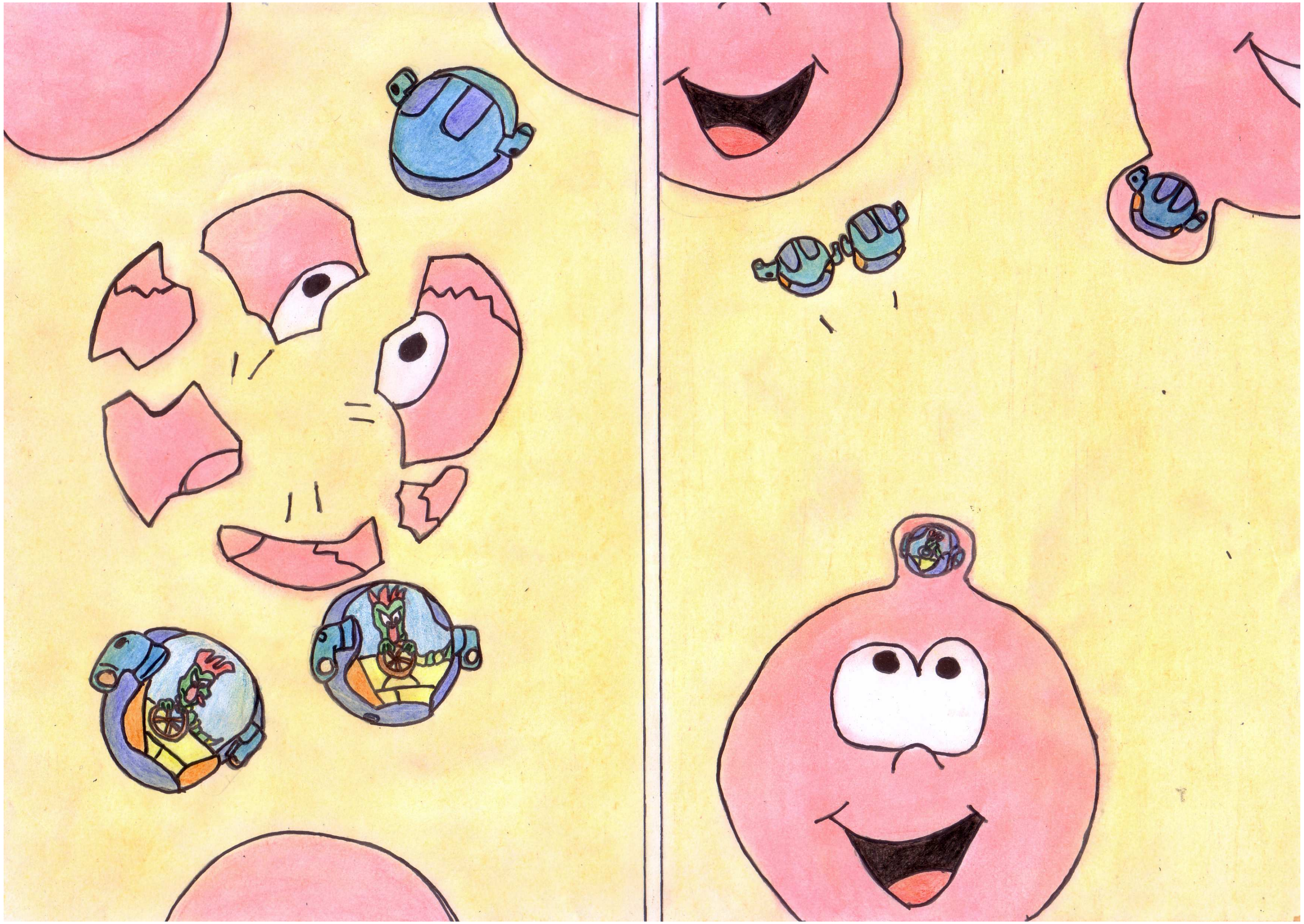
- Experiments by Lam et al. (2005)

$$c_{exp} = 73 \pm 17 \ \mu m/hr$$

NON-DELAYED MODEL



NON-DELAYED MODEL



MODELLING

- Extracelular model (Haseltine et al.): *4* adjusted parameters, classical reaction-diffusion equation.

$$\frac{\partial [V](r,t)}{\partial t} = D\frac{\partial^2 [V]}{\partial r^2} - k_1[V][C] + k_2 Y[I],$$

$$\frac{\partial [I](r,t)}{\partial t} = k_1[V][C] - k_2[I]$$

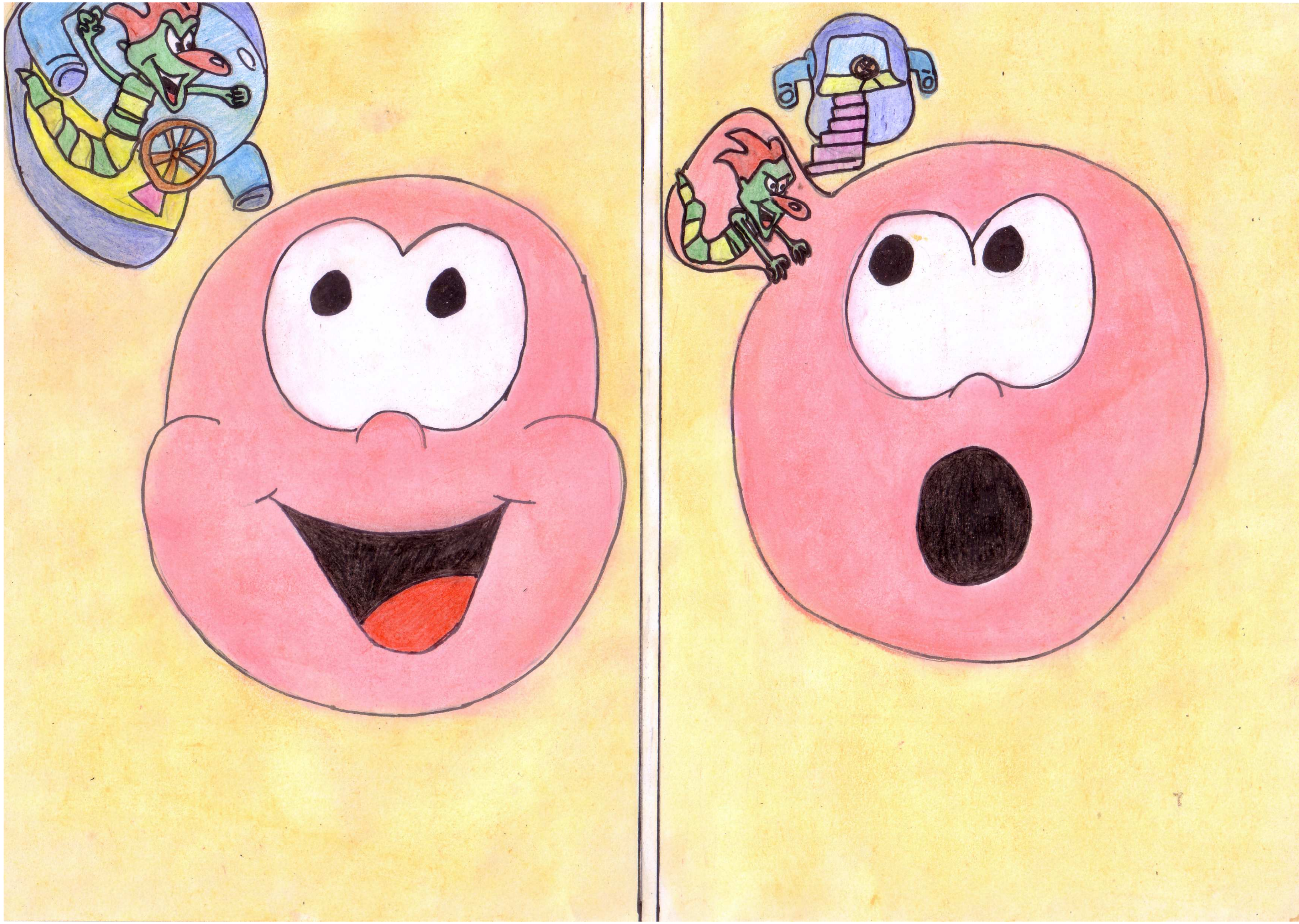
$$\frac{\partial C(r,t)}{\partial t} = -k_1[V][C],$$

- Hyperbolic reaction diffusion (HRD) equation was first applied to virus fronts in Fort and Méndez, Phys. Rev. Let. (2002).
- In our model we improved the HRD equation, in agreement with Isern and Fort, Phys. Rev. E (2009).

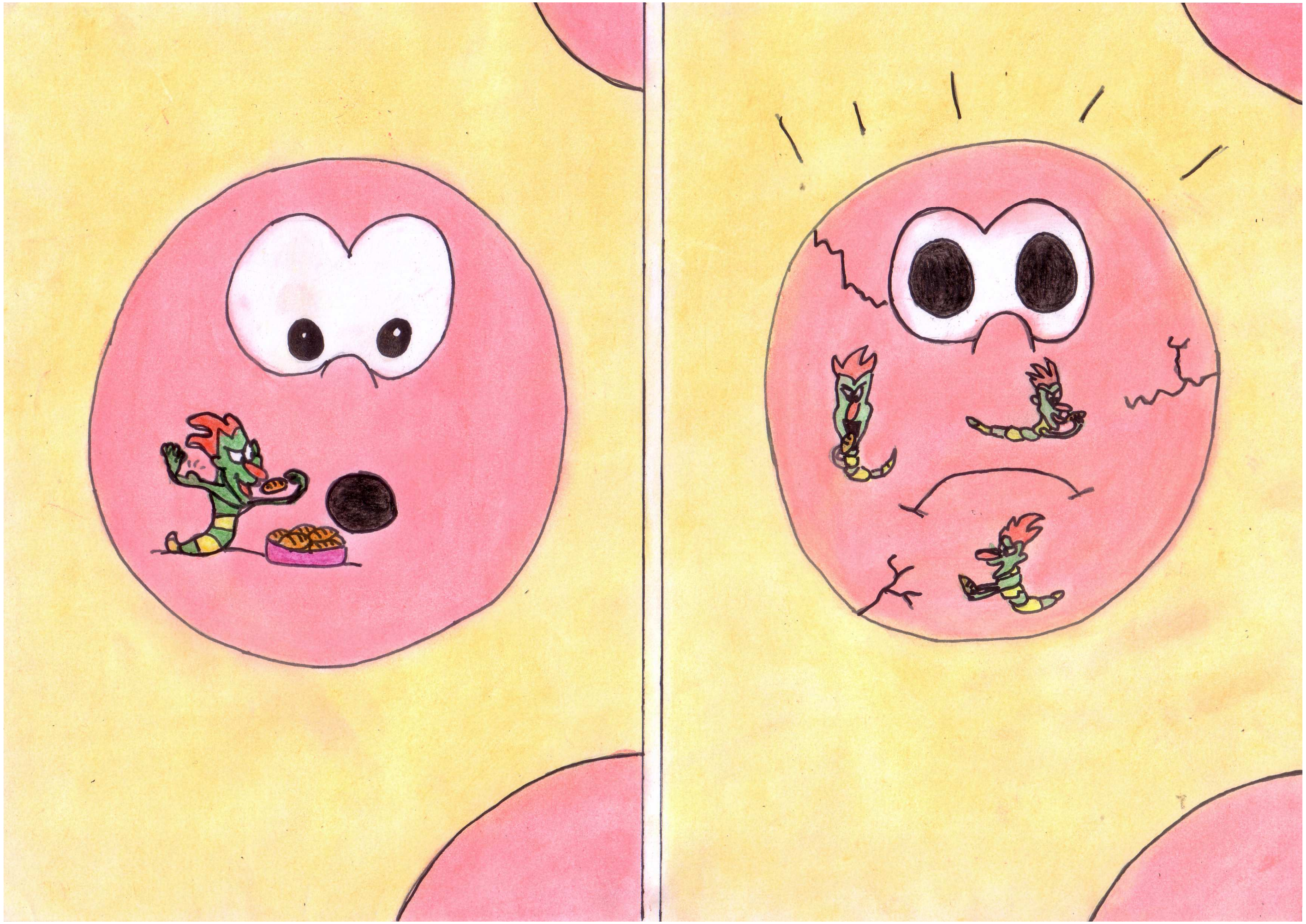
$$\frac{\partial [V](r,t)}{\partial t} + \frac{\tau}{2}\frac{\partial^2 [V](r,t)}{\partial t^2} = D\frac{\partial^2 [V]}{\partial r^2} + F(r,t) + \frac{\tau}{2}\left.\frac{\partial F(r,t)}{\partial t}\right|_g,$$

$$F(r,t) \equiv \left.\frac{\partial [V](r,t)}{\partial t}\right|_g = -k_1[V][C] + k_2 Y[I]$$

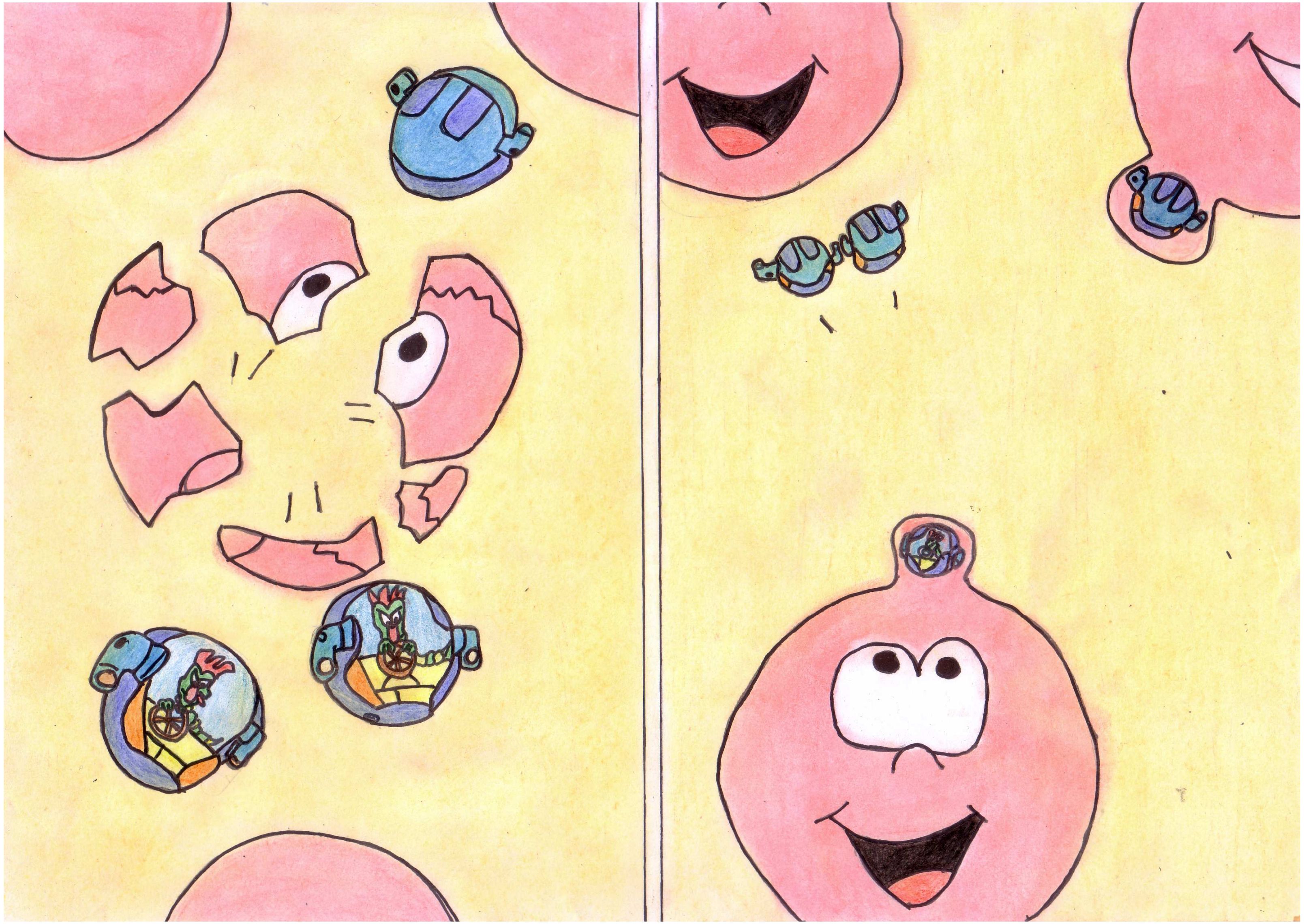
DELAYED MODEL



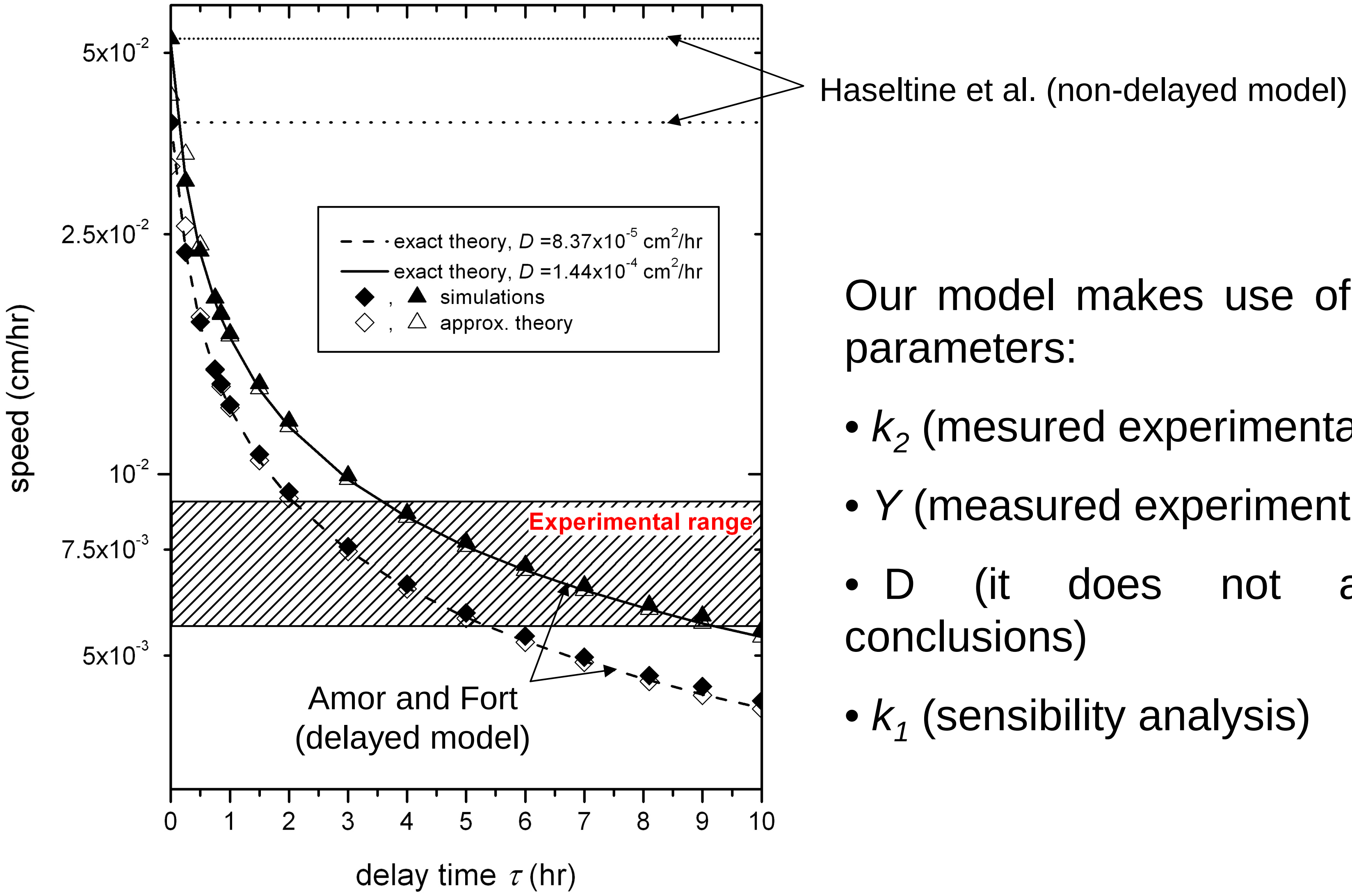
DELAYED MODEL



DELAYED MODEL



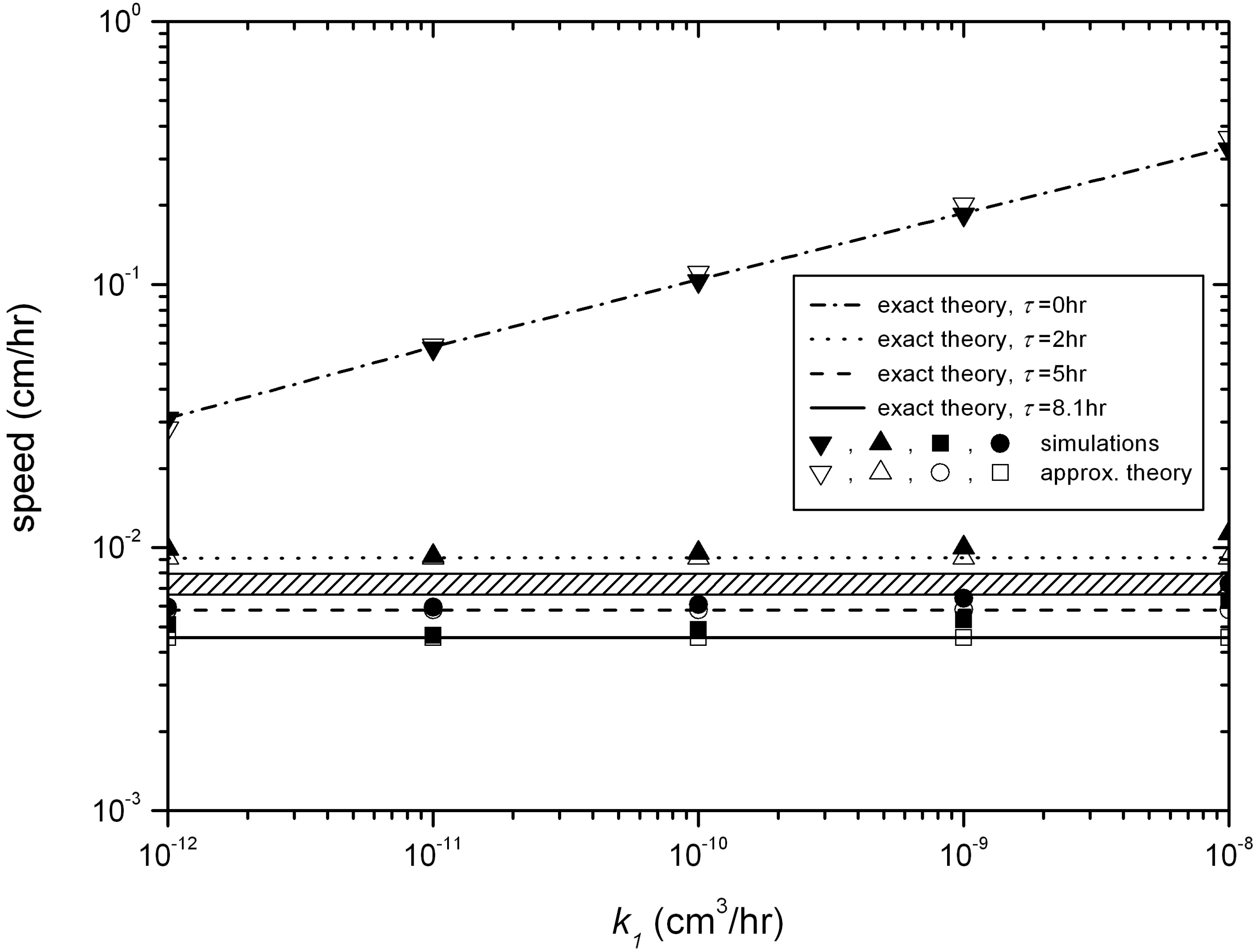
RESULTS



Our model makes use of four parameters:

- k_2 (mesured experimentally)
- Y (measured experimentally)
- D (it does not affect conclusions)
- k_1 (sensibility analysis)

RESULTS



speed (cm/hr)
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-12}
10^{-11}
10^{-10}
10^{-9}
10^{-8}
k_1 (cm^3/hr)
exact theory, τ =0hr
exact theory, τ =2hr
exact theory, τ =5hr
exact theory, τ =8.1hr
simulations
approx. theory

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- Front speed decreases with increasing values of the delay time .

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  Our model uses only two non-measured parameters which do not affect our main conclusions.

  In particular, high values of yield Y make results independent of k_1!

Thank you!

REFERENCES

- **D. Amor and J. Fort, Phys. Rev. E 82, 061905 (2010).**
- L. Haseltine, V. Lam, J. Yin, J. B. Rawlings, Bull. Math. Biol. 70, 1730 (2008).
- J. Fort and V. Méndez, Phys. Rev. Lett. 89, 178101 1 (2002).
- N. Isern, J. Fort, Phys. Rev. E 80, 057103 1 (2009).

ONE STEP GROWTH DATA