Incubation principles:

What does the embryo expect from us?

Ron Meijerhof

Poultry Performance Plus

'Value added' advice for poultry production

What does the embryo need?

- *Turning*
- Gas exchange
  - Uptake of oxygen
  - loss of carbondioxide
- Moisture loss
  - about 12-15%
- Heat transfer
  - heat balance

Carbohydr/yolk fat + oxygen → carbon dioxide + water + heat

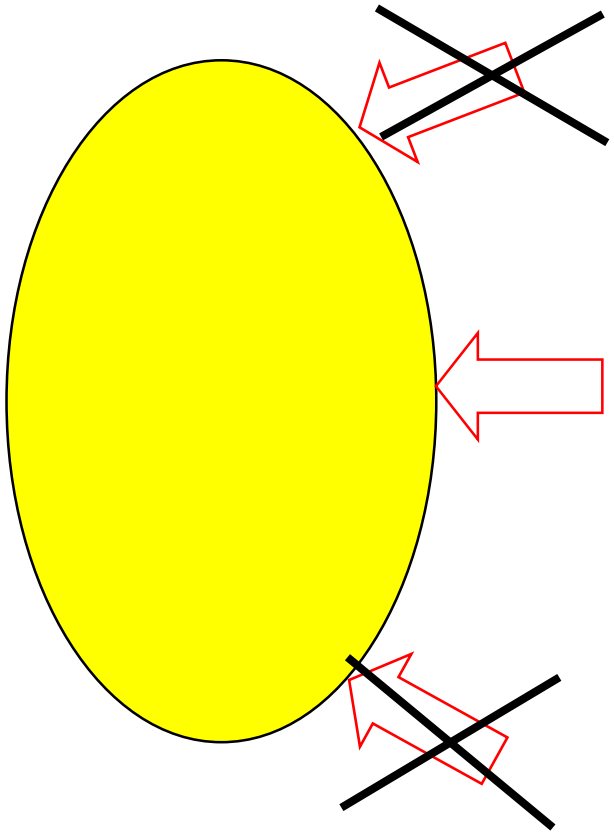
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_20 + e$

- Process controlled by temperature

but which temperature: external (air) or internal (embryo)?

Braun thermoscan “infrared ear thermometer”

Target: 100.0 - 100.5/101.0 F

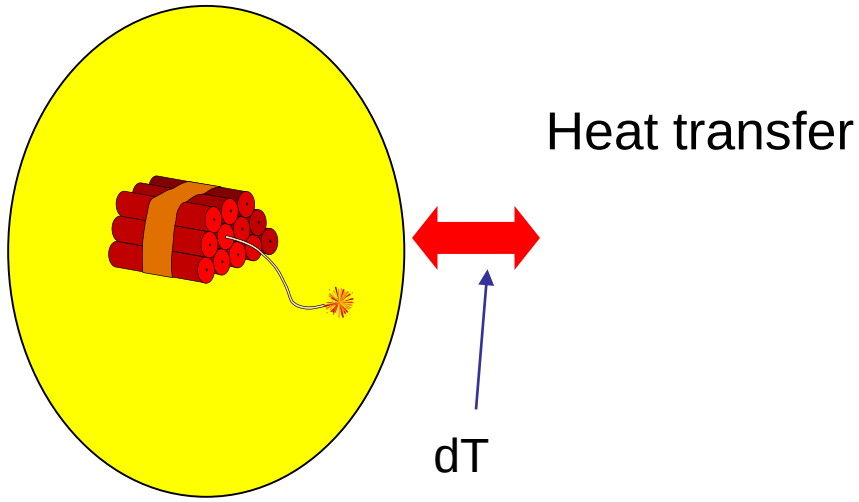


Embryo temperature

air? or embryo?

– Traditional incubators control air temperature

- as if embryo is equal or fully related with air temperature




98.9 °F
10 10:13

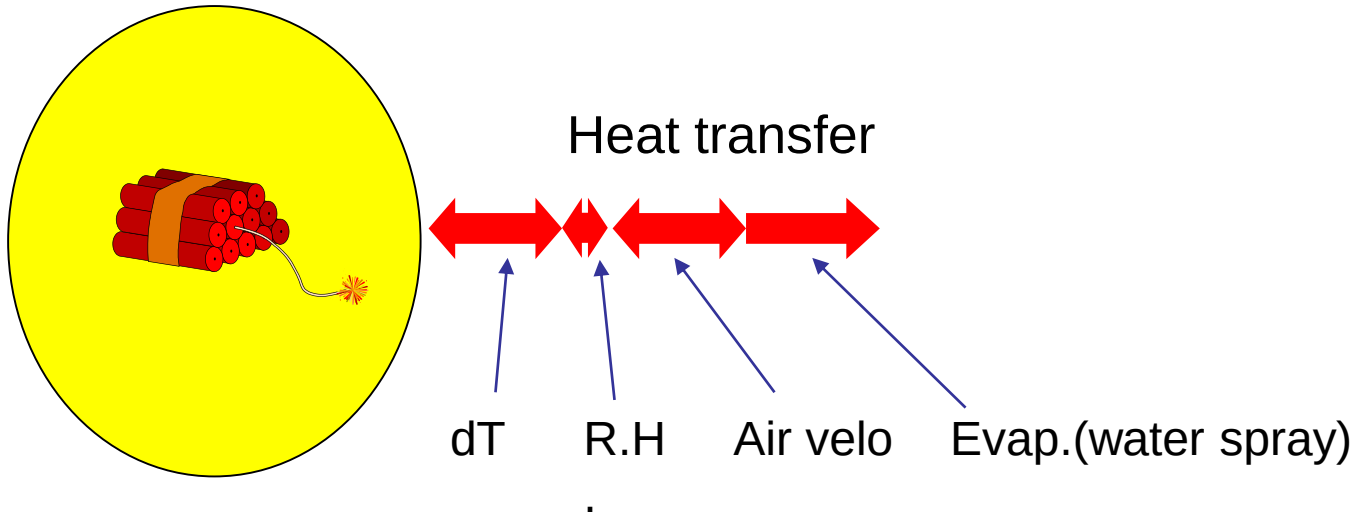

100.0 °F
10 10:06

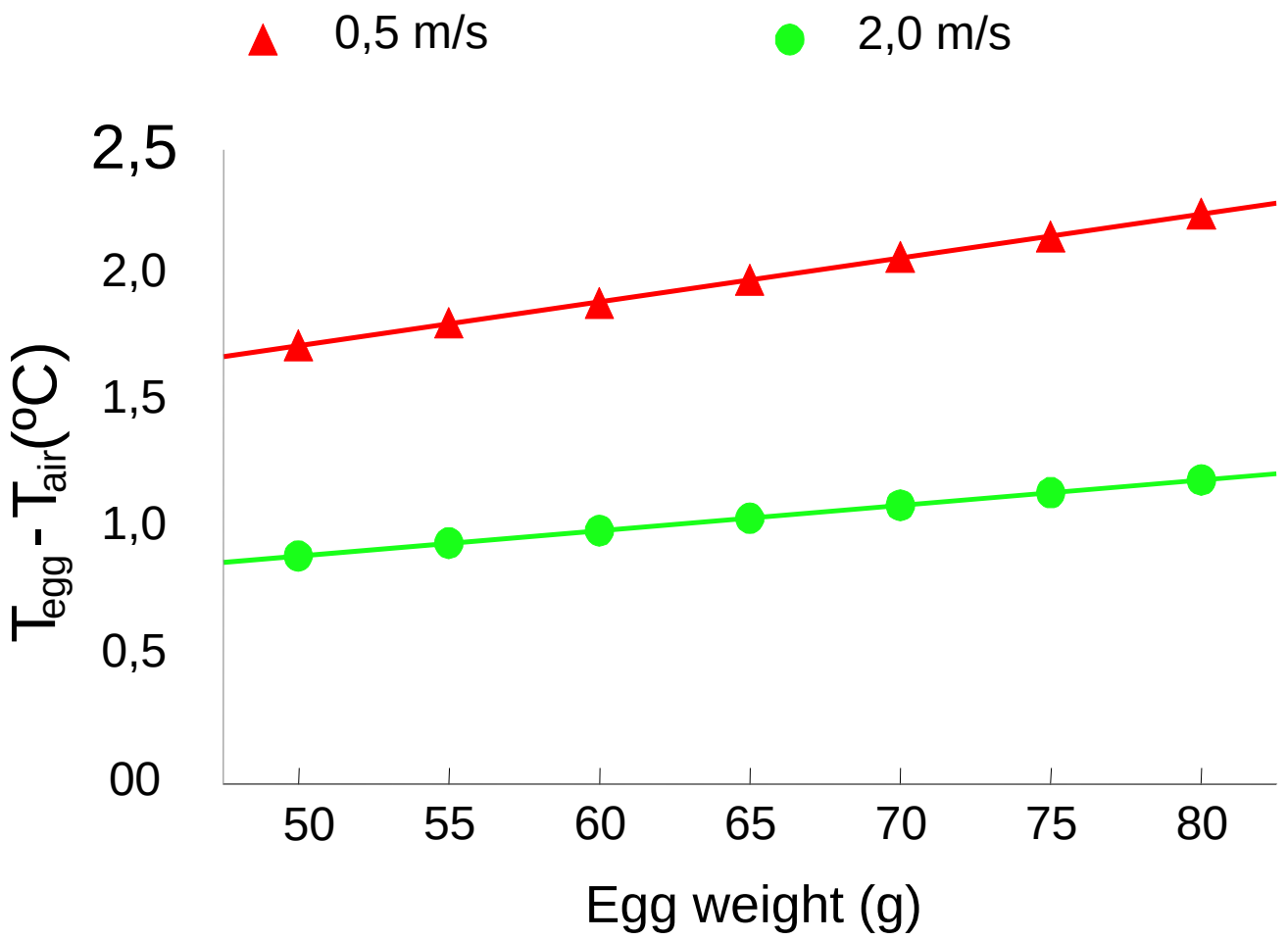

102.1 °F
10 9:52


103.5 °F

Air temp or heat transfer?

- Traditional incubators control air temperature
  - as if embryo is equal or fully related with air temperature
- embryo temperature is result of a balance between
  - heat production (breed, stage of incubation, temperature)
  - heat transfer (temp, heat capacity, air velocity, water spray)





Meijerhof and van Beek, 1993

Evaporation: cooling

Each gram of water costs 2.26 kJ energy to evaporate

100.000 eggs => 2 litre moisture loss/hr

constant cooling of –0.3^{o}F

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constant cooling of –0.3^{o}F

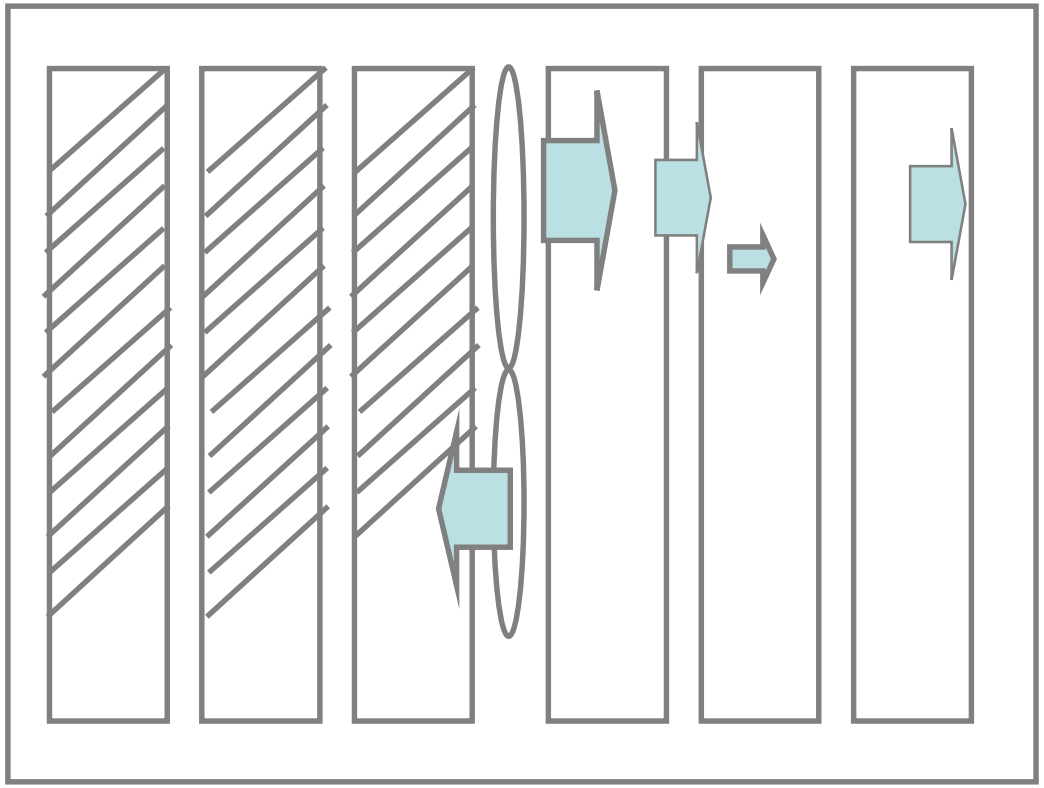
Ventilating 500 m^{3}/hr (20^{o}C, 50% R.H.)

6-7 litre of spraying water/hr

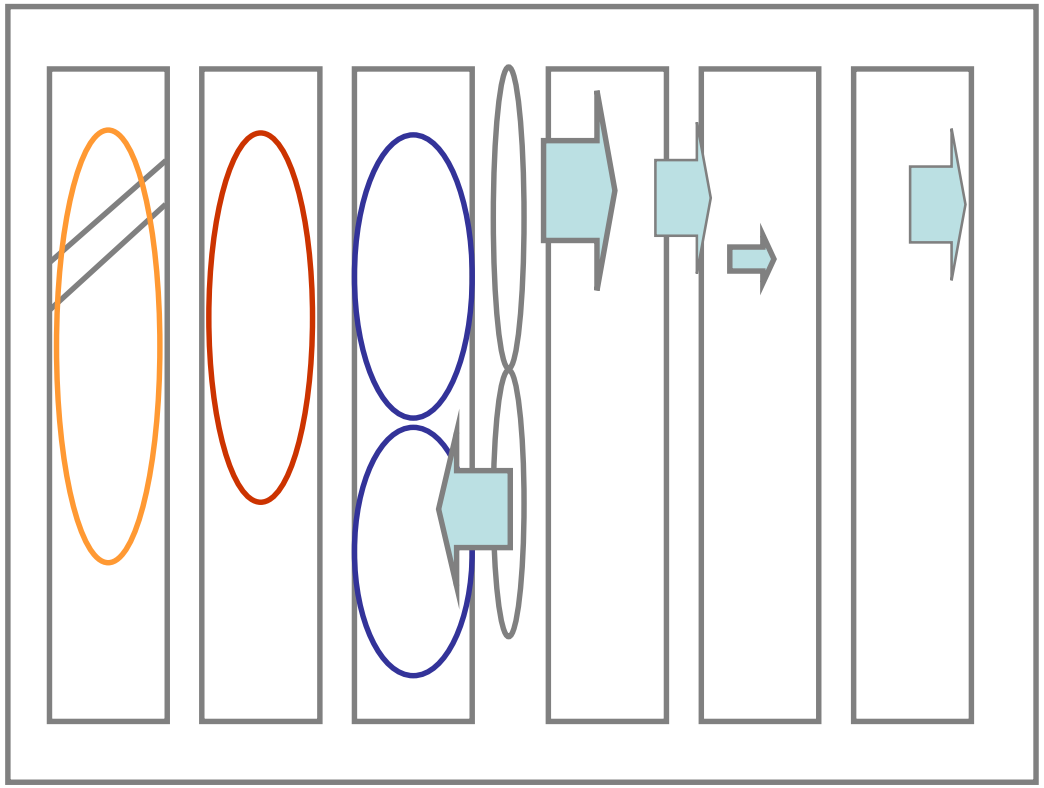
Constant cooling…

-1^{o}F if all eggs equally contribute

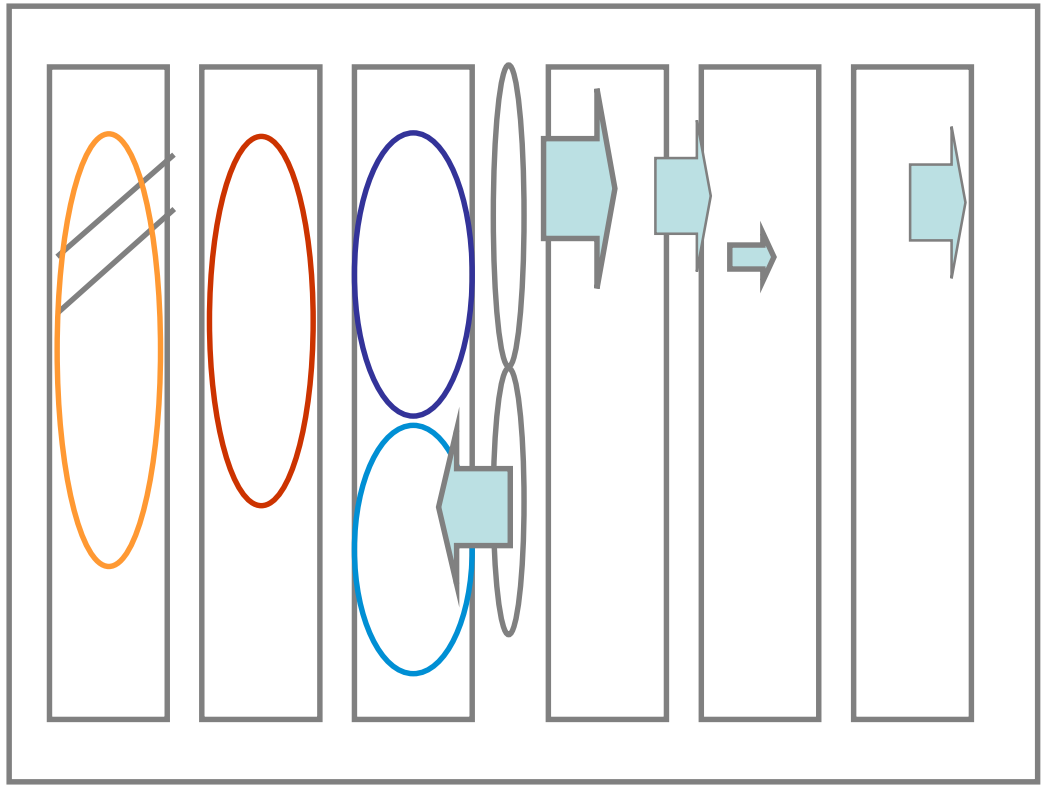
but do all eggs contribute???



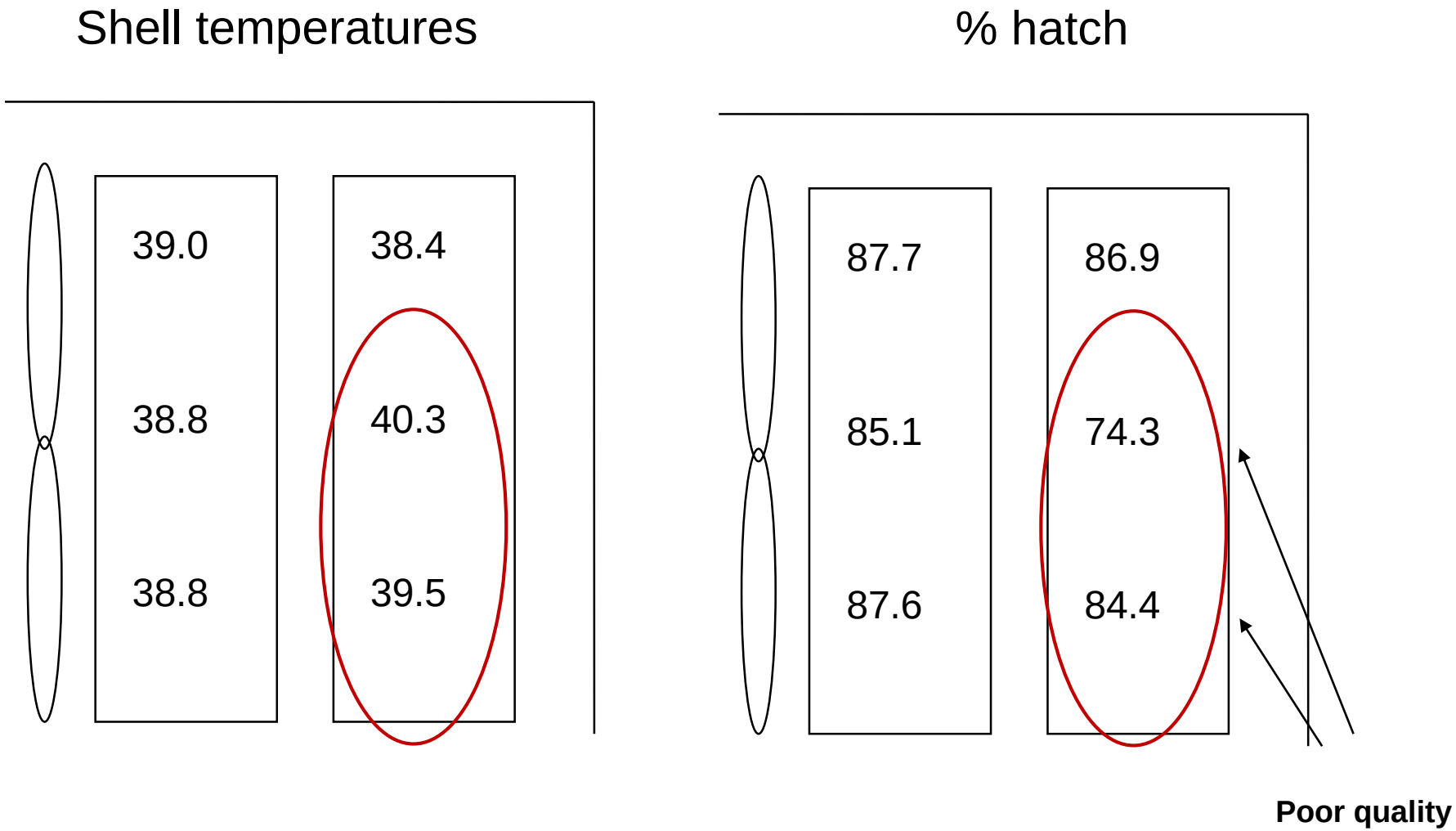
Modern single stage machine, front view



high air velocity: cold spots



high air velocity + water spray: very cold spots…



Lourens et al, 2001

What is optimum embryo temperature?
Is it 100ºF? Or 101-102ºF?

Optimum,
good hatch,
good quality

optimum

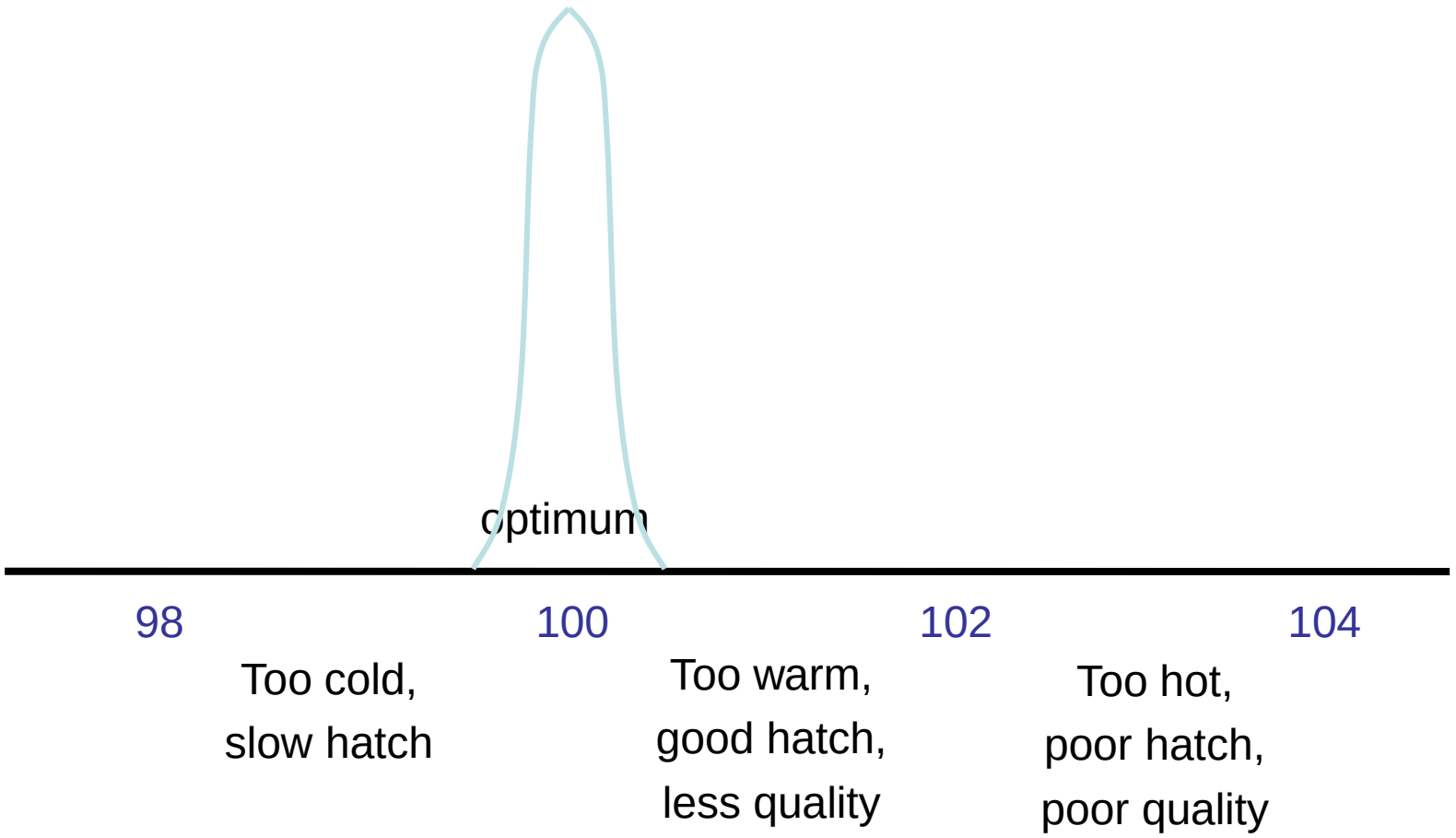
98 100 102 104

Too cold,
slow hatch

Too warm,
good hatch,
less quality

Too hot,
poor hatch,
poor quality

What is optimum embryo temperature?
Depends on spread and target…



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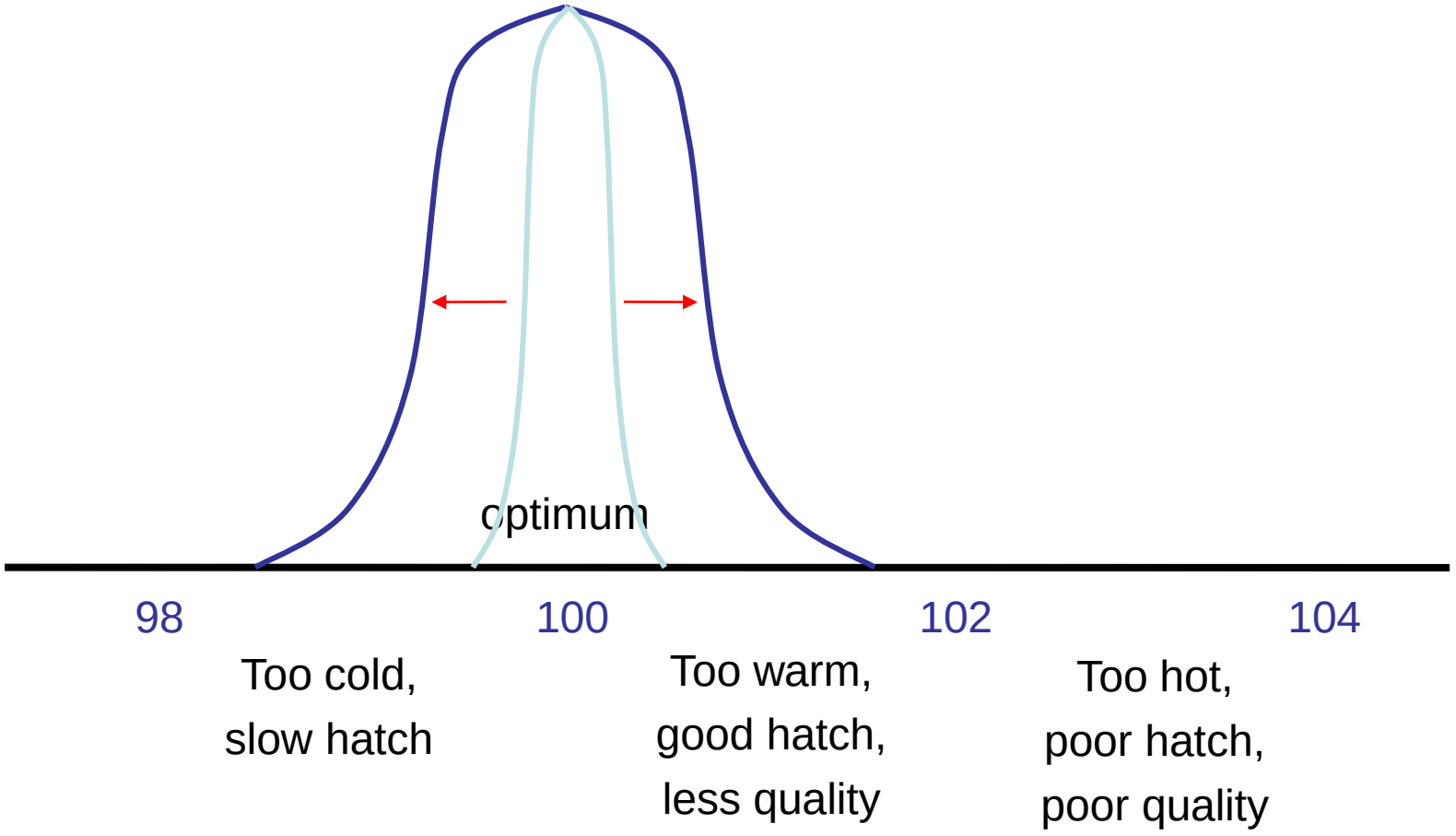

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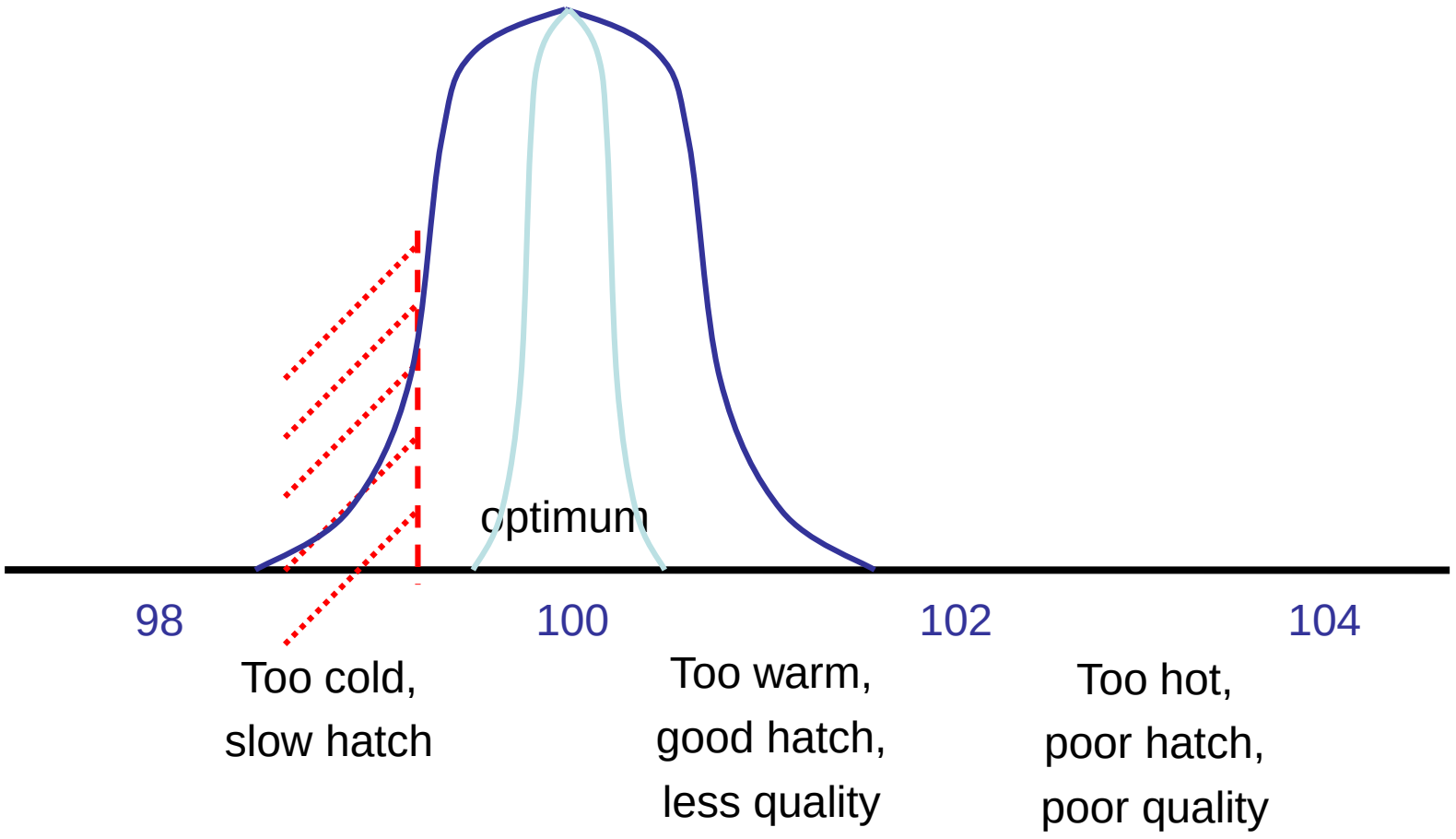
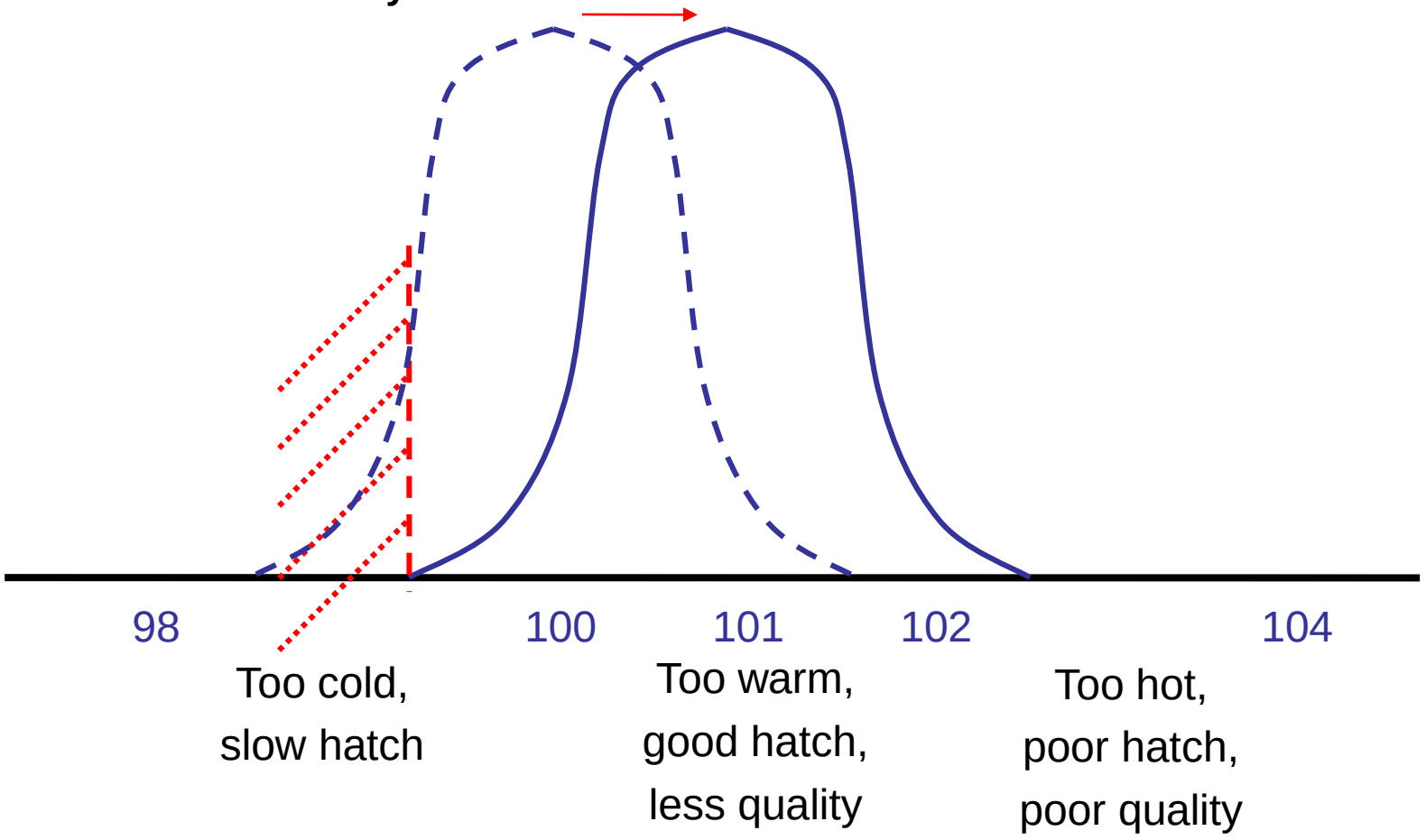


What is optimum embryo temperature?

Increased optimum if temperature not uniform…
Otherwise loss of hatchability

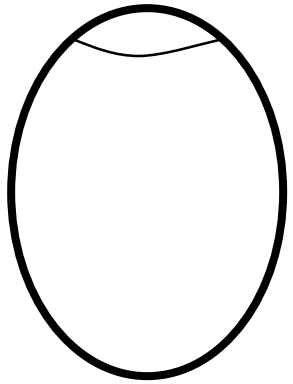


Relative humidity?

- So temperature is important.
- What about humidity (R.H.)?
  - Metabolic activity produces moisture (12-15%)
  - Moisture removal creates air cell
  - Air cell creates air “reservoir” for pipping
  - Relative humidity creates moisture loss

physical process driven by water vapour pressure deficit

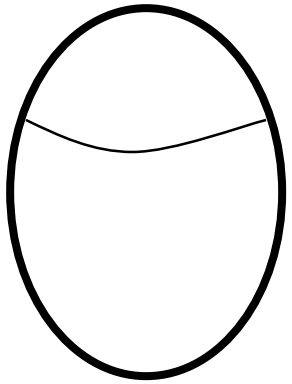
Not enough



drowning

smothering

Too much



dehydration

“sticking”

- 12-14% is optimum

But what is too much?

And what is not enough?

If it is so precise, how does the bird control it?

stops incubation when it starts to rain?

Eggs seem to hatch between 6-7 and 19-20% moisture loss

So why are we so concerned about moisture loss?

is 12 to 14% perhaps much too precise?

do birds care that much?

Eggs seem to hatch between 6 and 18% moisture loss
So why are we so concerned about moisture loss?

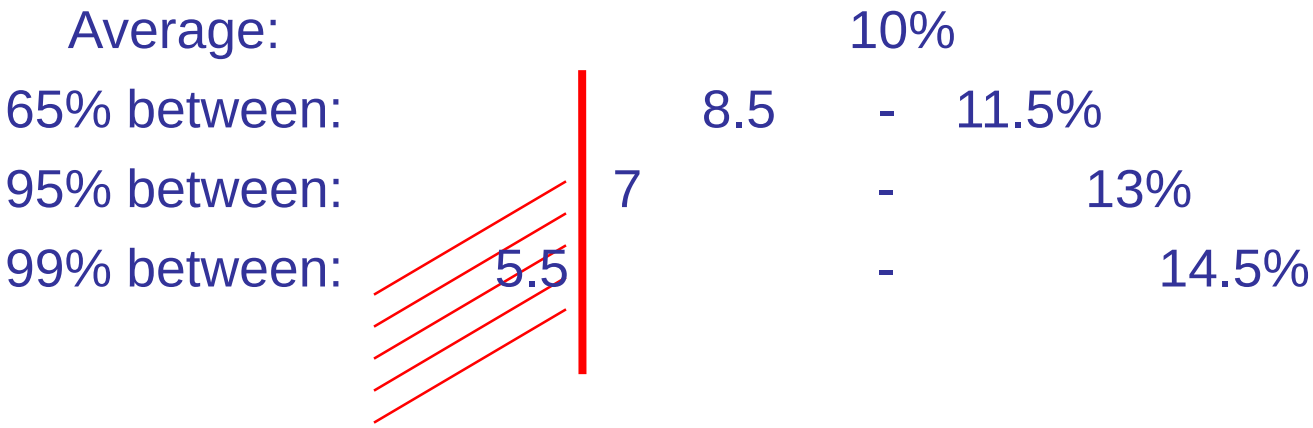
is 12 to 14% perhaps much too precise?
do birds care that much?

Huge variation in conductance between eggs

Standard deviation on individual eggs is approx 15-20%

Standard deviation on is approx 15%

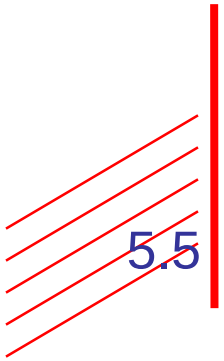
If average moisture loss is 10%:



Standard deviation on is approx 15%

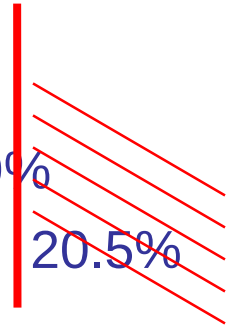
If average moisture loss is 10%:

Average:			10%	
65% between:		8.5	-	11.5%
95% between:	7		-	13%
99% between:	5.5		-	14.5%



If average moisture loss is 16%:

Average:			16%	
65% between:		14.5	-	17.5%
95% between:	13		-	19%
99% between:	11.5		-	20.5%



Standard deviation on is approx 15%

If average moisture loss is 12%:

Average:			12%	
65% between:		10.5	-	13.5%
95% between:	9		-	15%
99% between:	7.5		-	16.5%

If average moisture loss is 14%:

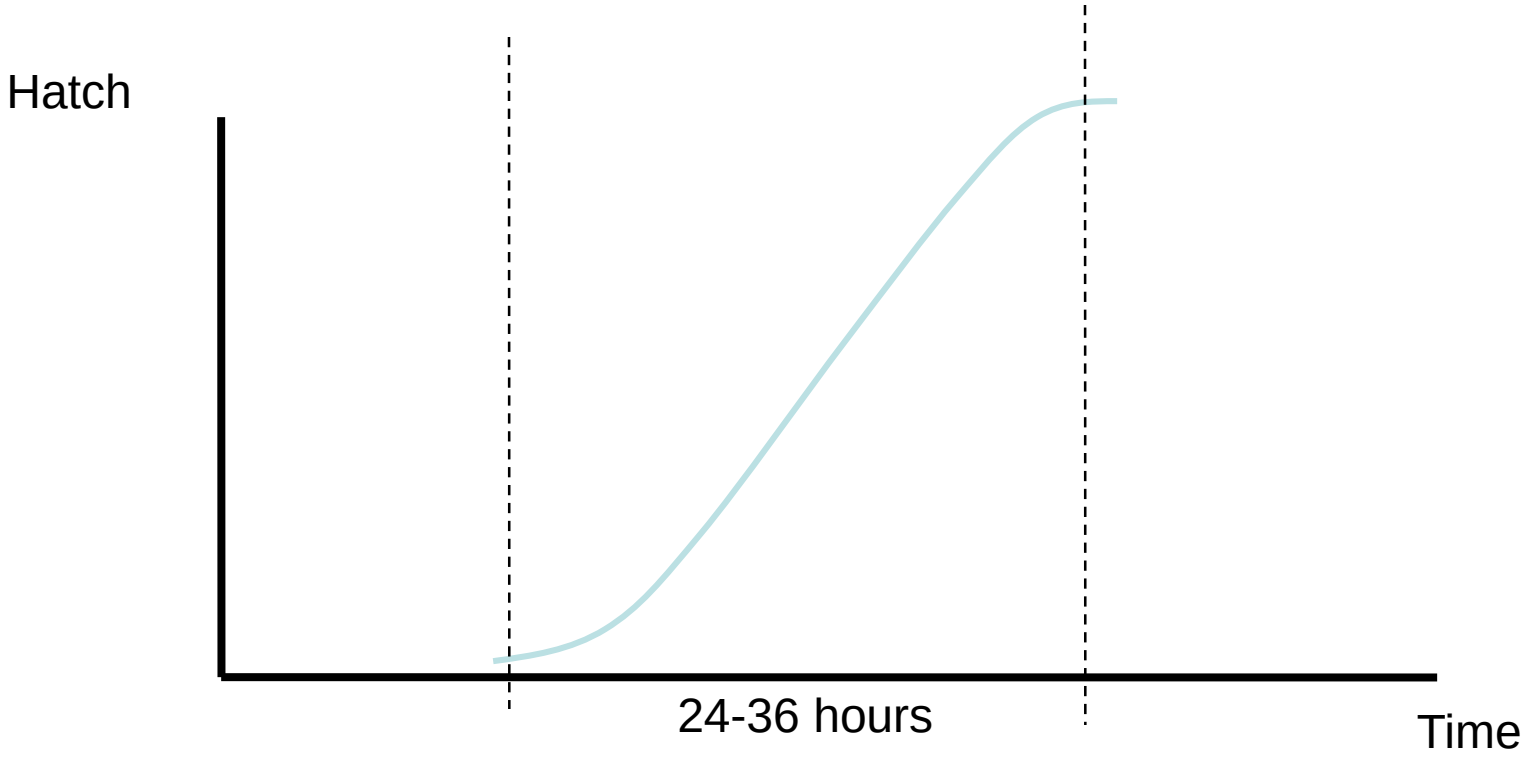
Average:			14%	
65% between:		12.5	-	15.5%
95% between:	11		-	17%
99% between:	9.5		-	18.5%

Standard deviation on is approx 15%

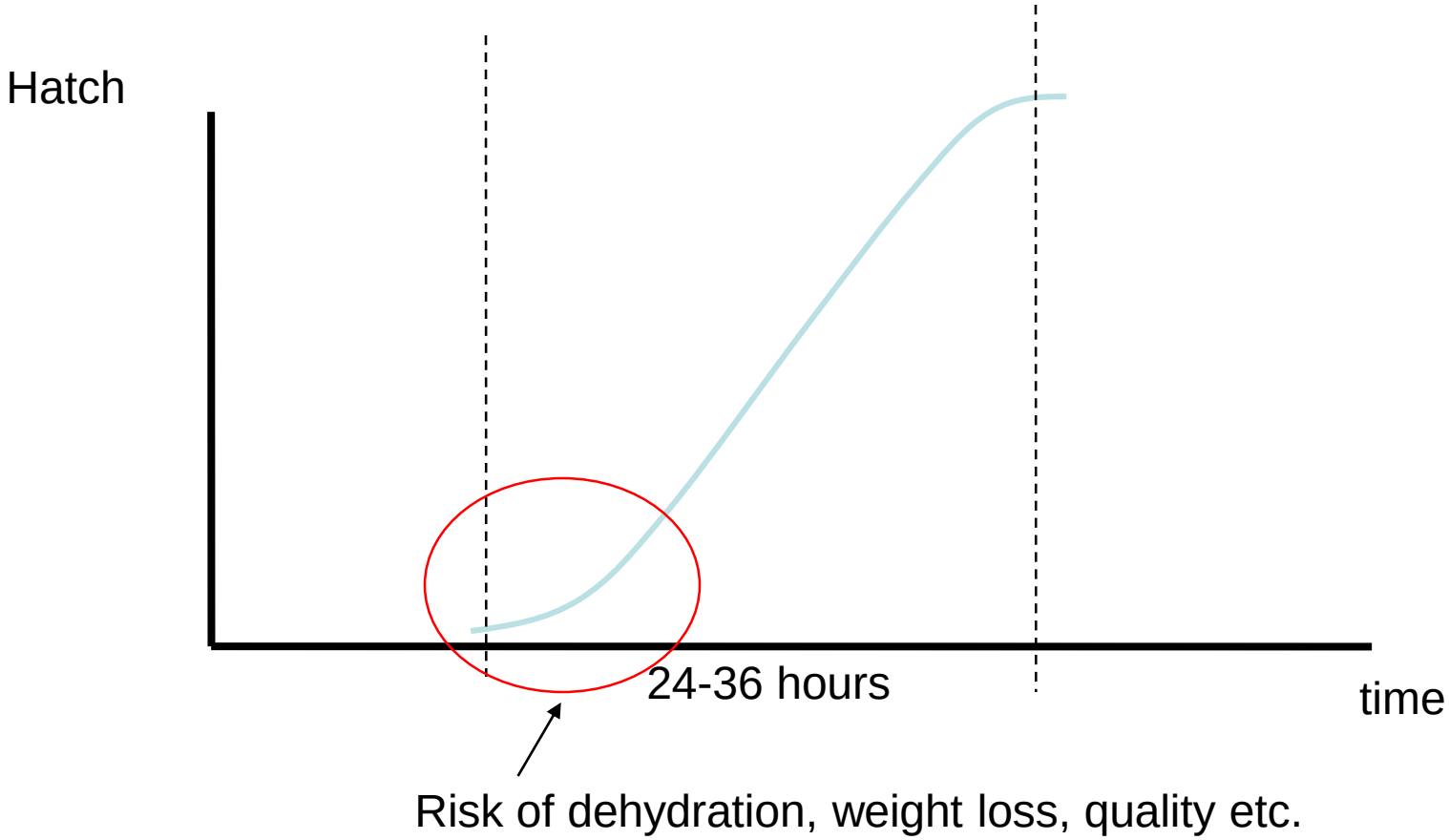
If average moisture loss is 10%:

Average:			10%	
65% between:		8.5	-	11.5%
95% between:	7		-	13%
99% between:	5.5		-	14.5%

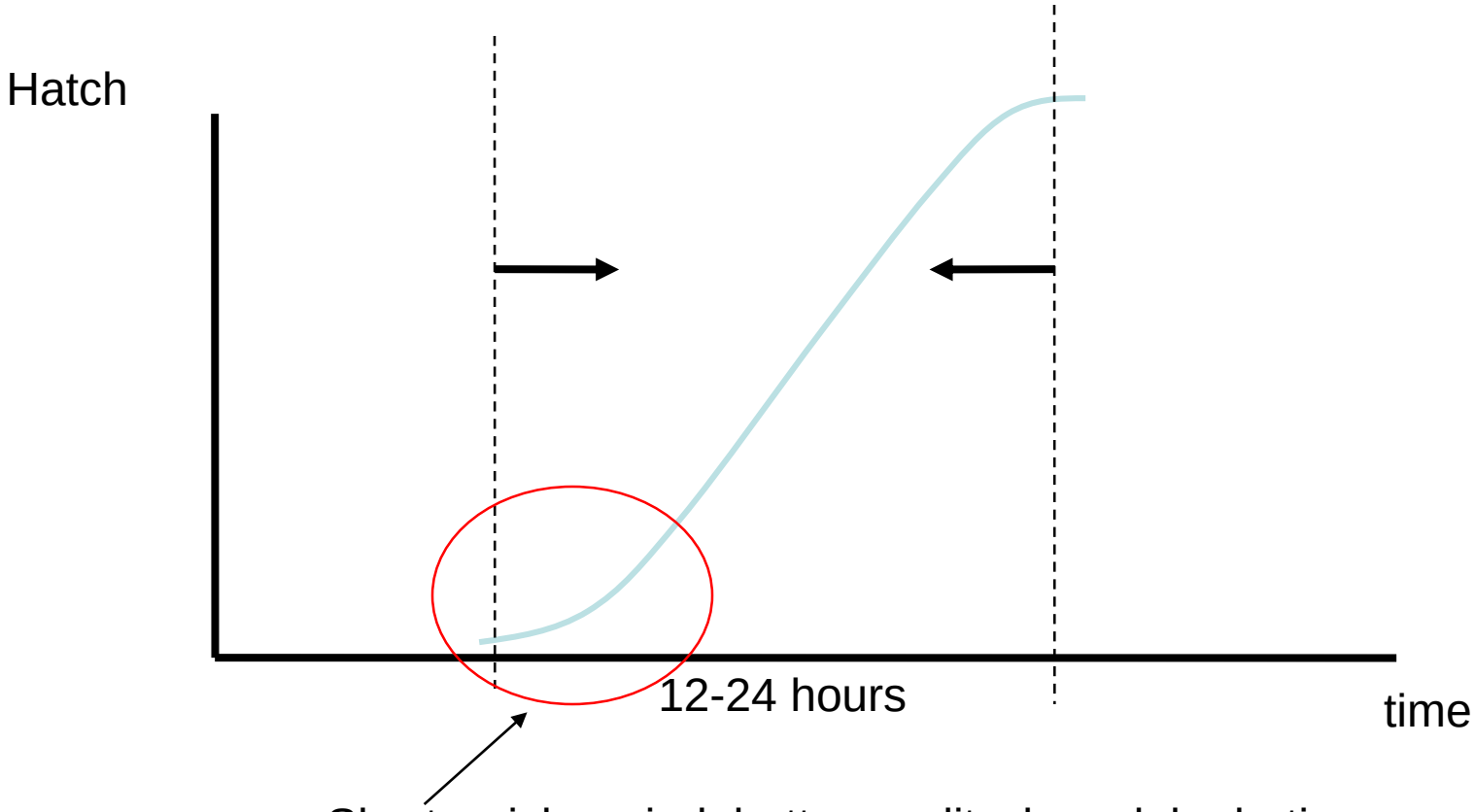
What about the famous hatch window…



The famous hatch window…



The famous hatch window…



How to decrease hatch window?

- Increase temperature (constant or fluctuating)
  - Stress birds, stimulate hatch process

- Increase CO_2 levels (6000-10.000 ppm)
  - Smother birds, stimulate hatch process…

  - Both work, and both work well, easy and efficient
  - But do birds like it? should it be done?
  - Should all pregnancies end at exactly 9 months, 0 days?

But why small hatch window?

- Because first chicks lose too much moisture
- So we can not transport chicks?
  - Of course we can, as long as we don’t overheat
- So problem of hatch window is not problem of holding..
  - It is problem of overheating…
- Solution: stress chicks out of the shell?
  - Or create hatcher that can hold chicks comfortably…
  - Dont solve hatcher problem by stressing chicks
  - But make better hatcher, or operate them better

Thank you for your attention!

Poultry Performance Plus

'Value added' advice for poultry production