Critical Values of the Chi-Squared Distribution

Probability (p)	Degrees of Freedom (df)				
	1	2	3	4	5
0.05	3.84	5.99	7.82	9.49	11.1

The formula for Chi-squared is:

$$X^2 = \Sigma\left[\frac{(o-e)^2}{e}\right]$$

where o = **observed** number of individuals

e = **expected** number of individuals

Σ = the **sum of the values** (in this case, the differences, squared, divided by the number expected)

2. Regulatory (control) mechanisms in organisms are necessary for survival. Choose **THREE** of the following examples and explain how each is **regulated**.

   (i) Flowering in plants

   (ii) Water balance in plants

   (iii) Water balance in terrestrial vertebrates

   (iv) Body temperature in terrestrial vertebrates

Question 2

Regulatory (control) mechanisms in organisms are necessary for survival. Choose **THREE** of the following examples and <u>explain</u> how each is **regulated**.

(i) Flowering in plants

(ii) Water balance in plants

(iii) Water balance in terrestrial vertebrates

(iv) Body temperature in terrestrial vertebrates

(i) Maximum 4 points

(each box represents an independent 1 point each)

change in photocycle/photoperiod	long day (short night) plants flower only if night is shorter than a critical duration - - - or - - - short day (long night) plants flower only if night exceeds a critical duration	phytochromes
		$P_r \Leftrightarrow P_{fr}$ (night) (day)
		unknown "florigen" converts
		shoot-meristem to floral-meristem
		or breaks bud dormancy
		leaf is photoreceptor organ
		gibberellins → ↑flowering
		auxins, ethylene, or abscisic acid→ ↓flowering
change in temperature pattern (vernalization)	specific duration of cold exposure - - - or - - - specified sequence of temperature changes initiate flowering	can be independent of (day neutral) or dependent on photocycle changes
		unknown "florigen" transitions shoot meristem to floral meristem or break bud dormancy
		gibberellins → ↑flowering
		auxins, ethylene, or abscisic acid→ ↓flowering
nutritional status	plant has enough nutritional resources to support flowering	can be independent (day neutral) or co-dependent of photocycle changes
		unknown "florigen" transitions shoot meristem to floral meristem
		or break bud dormancy
		gibberellins → ↑flowering
		auxins, ethylene, or abscisic acid→
		↓flowering

Question 2 (continued)

(ii) Maximum 4 points

Regulatory mechanism (must earn one "explanation point" before awarding a second "mechanism point")	**Explain how the regulatory mechanism affects water balance:** (2nd point must come from explanation before 3rd point can be awarded)	**Elaboration** (max 1 point)
- stomates/guard cells	closed ≈ ↓water loss (evap/transpir) open ≈ ↑water loss (evap/transpir)	ion, water influx/efflux from guard cells; turgid/flaccid (stomates: open/closed)
- altered stomate location or "sunken stomates"	stomates more abundant in more humid, cooler regions of the plant	
- cuticle thickening	↓water loss (evap/transpir)	waxy polymers resist water movements, cutin
- increased succulence	water storage	
- smaller leaves	↓water loss (evap/transpir)	
- drop leaves	↓water loss (evap/transpir)	abscisic acid
- altered leaf angle	↓water loss (evap/transpir)	less surface area directly exposed to sun's heat
- water potential in roots lower than that of soil	permits water uptake, even in saline soils	production of organic osmolytes in roots
- deeper root growth	reach deeper water	
- altered metabolic pattern (e.g., CAM)	stomates open only at night: ↓water loss (evap/transpir)	cooler, more humid conditions during the night
- increase cellular turgidity	opposes osmotic force	cell wall resists influx until pressure gradient offsets osmotic pressure

Question 2 (continued)

(iii) Maximum 4 points

Hypothalamus is water-regulation center (1 point max)	***Hypothalamus regulates neural circuits in behavior of thirst (1 point max)***

Regulatory mechanism/ detector/ signal (must earn one "explanation point" before awarding a second "mechanism point")	**Explain how the regulatory mechanism affects water balance.** (2nd point must come from explanation before 3rd point can be awarded)	**Elaboration** (1 point max)
Hyperosmotic conditions result in increased secretion of **Vasopressin (a.k.a. Anti-Diuretic Hormone = ADH)** from the hypothalamus/ (posterior) pituitary (gland) [[hyposmotic opposite]]	reduces water loss in urine [[hyposmotic opposite]]	↑ water permeability in descending limb of loop of Henle, distal tubule, or collecting duct causes greater reabsorption of water [[hyposmotic opposite]]
Hypovolemic conditions activate RAAS system (renin angiotensin activating system), especially **Ang II** from kidney/blood	Ang II increases (Na^+) and water reabsorption in proximal tubule; less urine	decreased renal blood pressure and filtrate flow increase renin release; renin activates angiotensinogen to Ang I, which is readily converted to Ang II juxtaglomerular apparatus (JGA)
Hypovolemic/ RAAS active Ang II stimulates **hypothalamic thirst** center	Ang II increases thirst	"dry mouth" perception
Hypovolemic/ RAAS active Ang II stimulates secretion of **aldosterone** from adrenal (cortex) gland	Aldosterone increases (Na^+) and water reabsorption (& K^+ secretion) in distal tubule	
Hypervolemic conditions (excess blood volume) cause increased secretion of **Atrial Natriuretic Peptide (ANP)**	decreases (Na^+) and water reabsorption in distal tubule	inhibits renin and aldosterone release; causes vasodilation of afferent arterioles
EVOLUTION		
- loop of Henle	loop length α urine osmolarity	
- type of nitrogenous waste	use less water in excretion	compare ammonia, urea, and uric acid for water solubility or toxicity
- development of specialized transport epithelia, e.g., salt glands	less water loss in osmoregulation	
- cloaca development	use less water in excretion	
- large intestine/ colon	greater surface area for water and ion absorption	
- water-resistant body surface	decrease water loss from body surface	
- behavioral avoidance of dessicating conditions	nocturnal habits reduce water loss due to heat	

Question 2 (continued)

(iv) Maximum 4 points

Hypothalamus is thermostat (1 point max)	*Thermostat reset by different conditions; autonomic/other neural outputs influence body temperature* (1 point max)	*Fever, hypothermia* (1 point max)
1 Regulatory mechanism (must earn one "explanation point" before awarding a second "mechanism point")	**Explain how the regulatory mechanism affects temperature regulation.** (2nd point must come from explanation before 3rd point can be awarded)	**Elaboration** (1 point max)
- move to a location that is: cooler if hot (e.g., shade), or warmer if cold (e.g., bask)	↑heat loss from body ↓heat loss from body	
- sweat/ perspire when hot	↑ evaporative cooling	
- lick body surface when hot	↑evaporative cooling	
- pant when hot	↑evaporative cooling	
- alter insulation (fur, feathers): flat when hot . . . . or erect when cold	↑heat loss ↓heat loss	↓boundary layer ↑boundary layer
- ↑ peripheral: vasodilation when hot, or vasoconstriction when cold	blood at periphery to ↑heat loss blood kept in core of body	
- ↑shivering when cold	↑heat production	contraction/relaxation cycling in skeletal muscles
- ↑non-shivering thermogenesis when cold	↑heat production	metabolism of brown fat
- ↑activity when cold	↑metabolic heat production	
- activate heat-shock proteins when hot	intracelluar protection of protein structure	HSPs are chaperones that guide protein folding
- torpor estivate when hot . . . . or hibernate when cold	↓ activity & ↓ metabolism → ↓ metabolic heat ----------------------------------- ↓activity and slower metabolism ↓ heat loss during cold winter	sometimes triggered by changes in day length sometimes triggered by changes in day length
- ↑ surface area (e.g., big ears) - ↓ surface area	↑heat loss ↓heat loss	
- ↓body fat	↑heat loss	
- shed insulation when hot - grow insulation when cold	↑heat loss ↓heat loss	↑boundary layer
- ↑metabolic rate when cold - ↓metabolic rate when hot	↑heat production ↓heat production	↑thyroid hormones ↓thyroid hormones
- ↓surface area:volume	↓heat loss	
- counter-current heat exchange/blood flow	↓heat loss by keeping core warmer than periphery	heat transferred from arterial to venous vessels