**Review Worksheet Answers – Adaptations for Bipedalism**

1: Define the terms bipedalism and quadrupedalism.

(2 marks)

*Bipedalism is locomotion on two legs (1) (as seen in humans and recent, extinct, human ancestors). Quadrupedalism is locomotion on all four limbs (1) (as seen in many mammals, and close human relatives such as gorillas and chimps)*

2: Discuss the environmental changes that contributed to the evolution of bipedalism.

(6 marks)

*Hominins initially lived in a woodland environment (0.5) so hands, feet and posture were suited to an arboreal lifestyle (0.5). 5-6 million years ago (0.5), changes to the climate caused falling temperatures (0.5) and reduced rainfall (0.5), resulting in an increase in open grasslands (0.5) and a decrease in forest areas.*

3: Why was bipedalism a selective advantage in open grassland environments?

(3 marks)

* + *Bipedalism is a more energy efficient mode of locomotion on the ground (0.5)*
  + *Increased range of vision to detect prey and predators (0.5)*
  + *Increased apparent height/size deterred predators (0.5)*
  + *Hands free for carrying food and babies, using tools (0.5)*
  + *Higher reach to pick fruit or collect honey (0.5)*
  + *Less exposure to sunlight, greater surface areas for breezes – better temperature regulation in open grassland. (0.5)*

4: What additional factor caused a struggle for existence in the environment, placing selection pressure?

*Due to the change in climate (0.5), food sources became more limited (0.5), meaning the impact of evolutionary changes such as bipedalism were increased (1).*

5: List anatomical adaptations for erect posture/bipedalism seen in humans and bipedal human ancestors.

(5 marks)

* + *Position of Foramen Magnum and Skull*
  + *Curve of spinal Column*
  + *Jaw (reduced prognathism)*
  + *Pelvis*
  + *Carrying angle*
  + *Knee*
  + *Foot*
  + *Centre of Gravity*
  + *Stance and muscle tone*
  + *Striding gait*

6: Fill in the tables on the following pages giving detailed explanation for adaptations for bipedalism, advantages of each adaptation and comparison with related quadrupeds.

(32 marks)

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| **Structure** | **Adaptations for Bipedalism** | **Advantages of the Adaptation** | **Comparison with Related Quadrupeds** |
| Position of Foramen Magnum and Skull | *Foramen Magnum central at base of skull. (0.5)*  *Skull balanced on top of spinal column (0.5)* | *FM allows face to be forward while upright. (0.5)*  *Reduces muscular mass and strength required to support head (0.5)* | *FM towards back of skull – allows face to be forward while on all four legs. (0.5)*  *Muscles support head at end of neck. (0.5)* |
| Curvature of Spinal Column | *Double curvature: S-shaped curve of spine (0.5)*  *Lumbar spine has wedged vertebrae for forward curve (0.5)*  *Curve of upper spine brings centre of gravity of skull over the vertebral column (0.5)* | *Improves balance of body while upright (0.5)*  *Allows weight of skull to be carried on top of vertebral column, reducing muscle and strength required. (0.5)* | *C-shaped spine (0.5) allows for muscle attachment of trunk and neck to hold head in position (0.5)* |
| Jaw (reduced prognathism) | *Jaw is much flatter to the face – does not jut out to form a muzzle (0.5)* | *Allows skull to balance better on vertebral column (0.5) by preventing front of skull from being heavier than back (0.5) less muscle and energy needed to maintain posture and raise head. (0.5)* | *Jaw juts out into a pronounced muzzle (0.5)* |
| Pelvis | *Broad, flat, short, bowl shaped pelvis (1)* | *Supports abdominal organs when standing up (0.5)*  *Supports developing foetus in female (0.5)*  *Female pelvis slightly broader than male –makes birth possible (0.5)*  *Broad hip bones – attachment for large buttocks (0.5) to move legs, and keep upper body erect (0.5)* | *Long, narrow pelvis (0.5)* |
| Carrying Angle | *Hip joint under trunk and head and wide apart (0.5)*  *Femur well fitted within socket (0.5)*  *Femurs angle in towards knees (0.5)* | *Ensures weight distribution stays close to central axis of body (0.5)*  *Allows upright, stable, striding gait, rather than side to side rocking gait seen in apes (0.5)*  *Weight transmission falls outside femur (0.5)* | *Femur straight from hip to knee. (0.5)* |

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| **Structure** | **Adaptations for Bipedalism** | **Advantages of the Adaptation** | **Comparison with Related Quadrupeds** |
| Knee | *Joint is angled due to femur position transmitting weight to outside of knee. (0.5)*  *Centre of gravity falls just in front of knees. (0.5)* | *Shaping of joint allows outer aspect of joint to be stronger (0.5) to cope with weight transmission.*  *Force pushes to bend knee backwards, resisted by knee ligaments (0.5)*  *Natural resistance of joint requires no energy to hold body in standing position (0.5)* | *Joint is not angled (0.5)* |
| Foot (and lower leg) | *Tibia larger and stronger than fibula (0.5)*  *Platform foot – reduced flexibility, limited prehensility, no opposability. (0.5)*  *Metatarsals form longitudinal and transverse arches. (0.5)* | *Allows for pattern of weight transmission (0.5)*  *Platform foot provides stability when walking upright (0.5)*  *Metatarsal arches provide shock absorption (0.5) and allow for rolling gait (0.5)* | *Feet are prehensile with opposable toes. (0.5) Not as stable for maintaining stance, but good for arboreal lifestyle – can maintain grip. (0.5)* |
| Centre of Gravity | *Low centre of gravity – in pelvis (0.5)*  *Legs longer than arms (0.5)* | *Low centre of gravity makes balancing easier during standing and walking (0.5)*  *Long legs compared to arms contribute to low centre of gravity (0.5)* | *Longer arms and centre of gravity in chest (0.5) allow for more efficient quadrupedal locomotion.* |
| Stance and Muscle Tone | *Upright stance (0.5)*  *Muscle tone causes partial contraction of muscles in spine, abs, hip, knee and ankle (0.5)* | *Upright stance allows for efficient bipedal motion. (0.5)*  *Muscle tone allows upright stance to be easily maintained (0.5)* | *Have difficulty maintaining upright stance (0.5)* |
| Striding Gait | *Forward, striding gait, minimal swaying. (0.5)*  *Trunk rotates around pelvis, arms swing (0.5)*  *Arches of foot allow rolling movement (0.5)* | *Striding gait is energy efficient (0.5)and allows for speed and stability (0.5)* | *Swaying, inefficient gait when upright (0.5)* |



13: Describe the Bottleneck Effect on allele frequency and give an example.

(15 marks)

*The bottleneck effect occurs when an event such as a natural disaster (1) randomly kills the majority of a population (1), leaving a surviving population that is a small sample of the original (1). Due to variation within a population (1), the small population of survivors are likely to have a different allele frequency (1) than the original population (1). Once the population reproduces, the new population will have a different gene frequency to the original population (1).*

*An example of the Bottleneck Effect is the islanders of Pingelap(1). In 1775, a typhoon killed the majority of islanders (1). There were only 20 remaining survivors (1), and of these, one was carrying an allele for achromatopsia (1), a form of colourblindness. Over time, reproduction within the small population meant that the allele for achromatopsia remained in the population (1), so that the incidence of achromatopsia on Pingelap remained at around 5% (1), with 30% carrying the allele (1). In comparison, the incidence of achromatopsia worldwide is far lower (1): 0.003%. The bottleneck effect is responsible for the greatly increased allele frequency for achromatopsia on Pingelap. (1)*