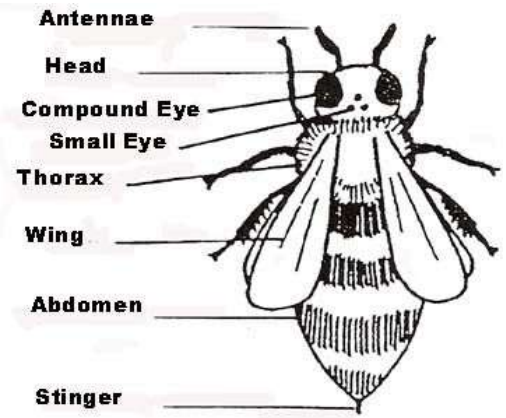
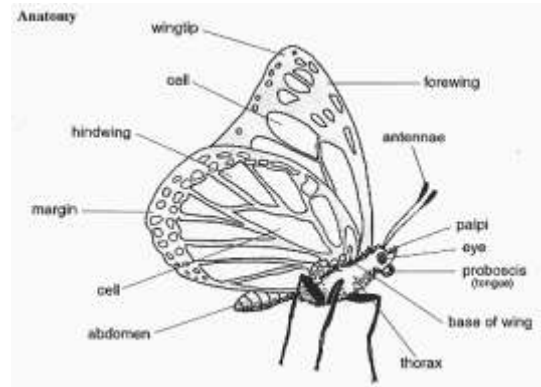
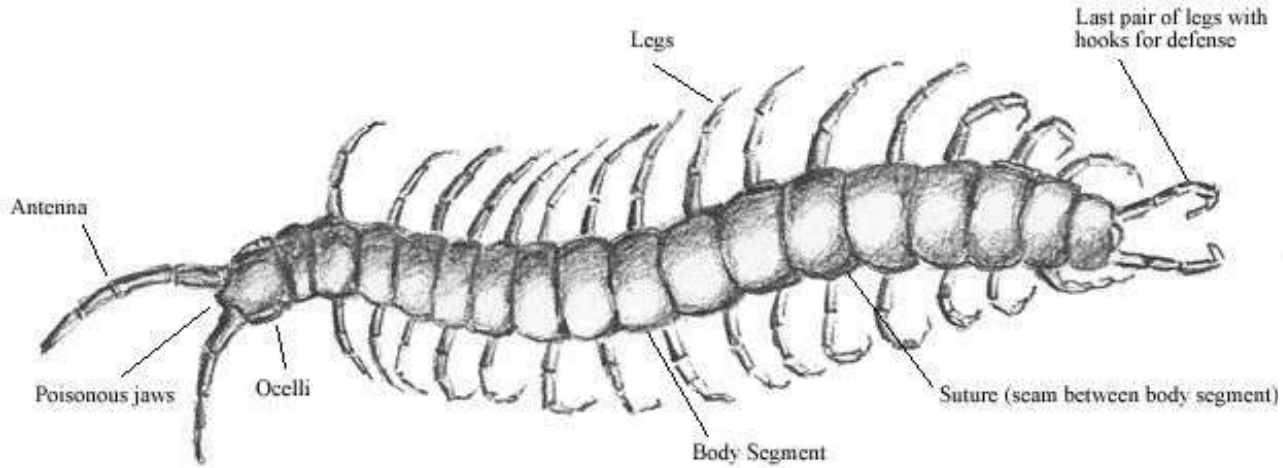
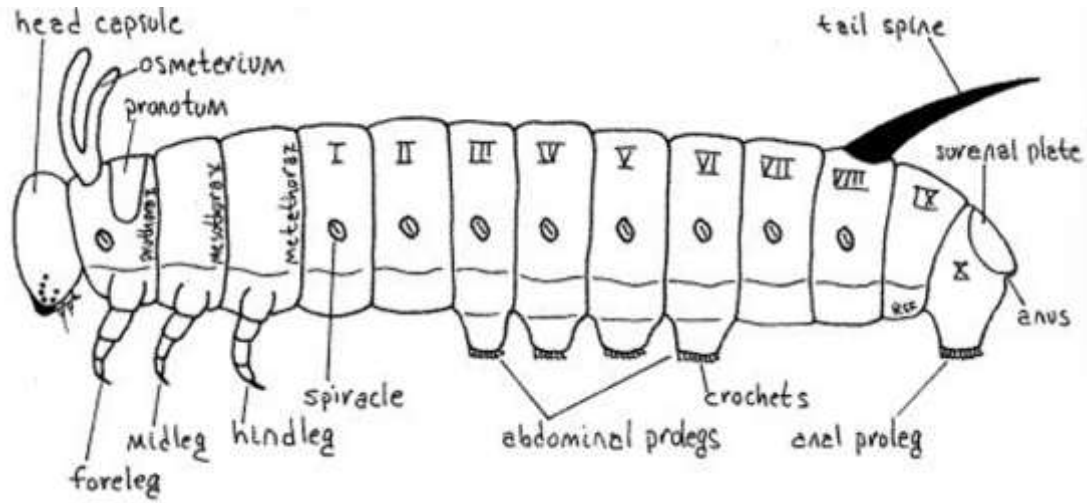


Insects & Bugs (Arthropod Locomotion in Animation)









How do arthropods move?

- **Flying-Bee, Butterfly**
- **Walking-Ant**
- **Crawling- Centipede, Caterpillar**







Ant gait

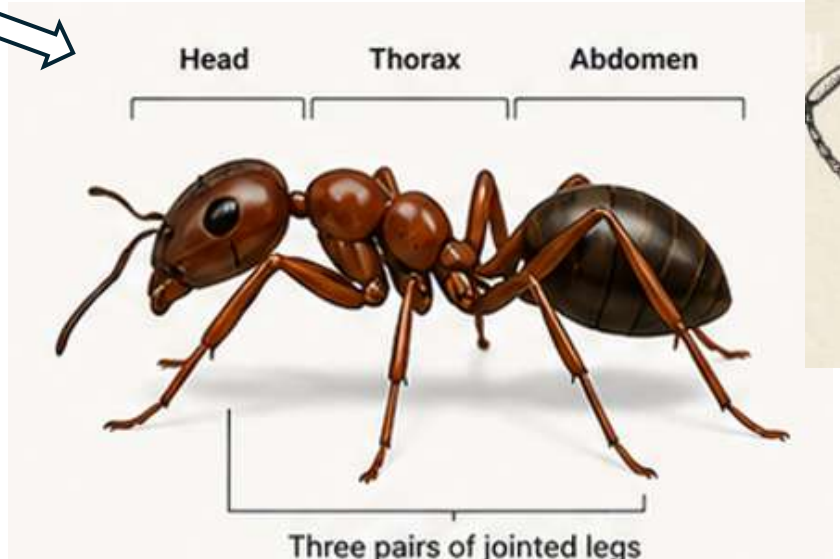
1.Body Structure

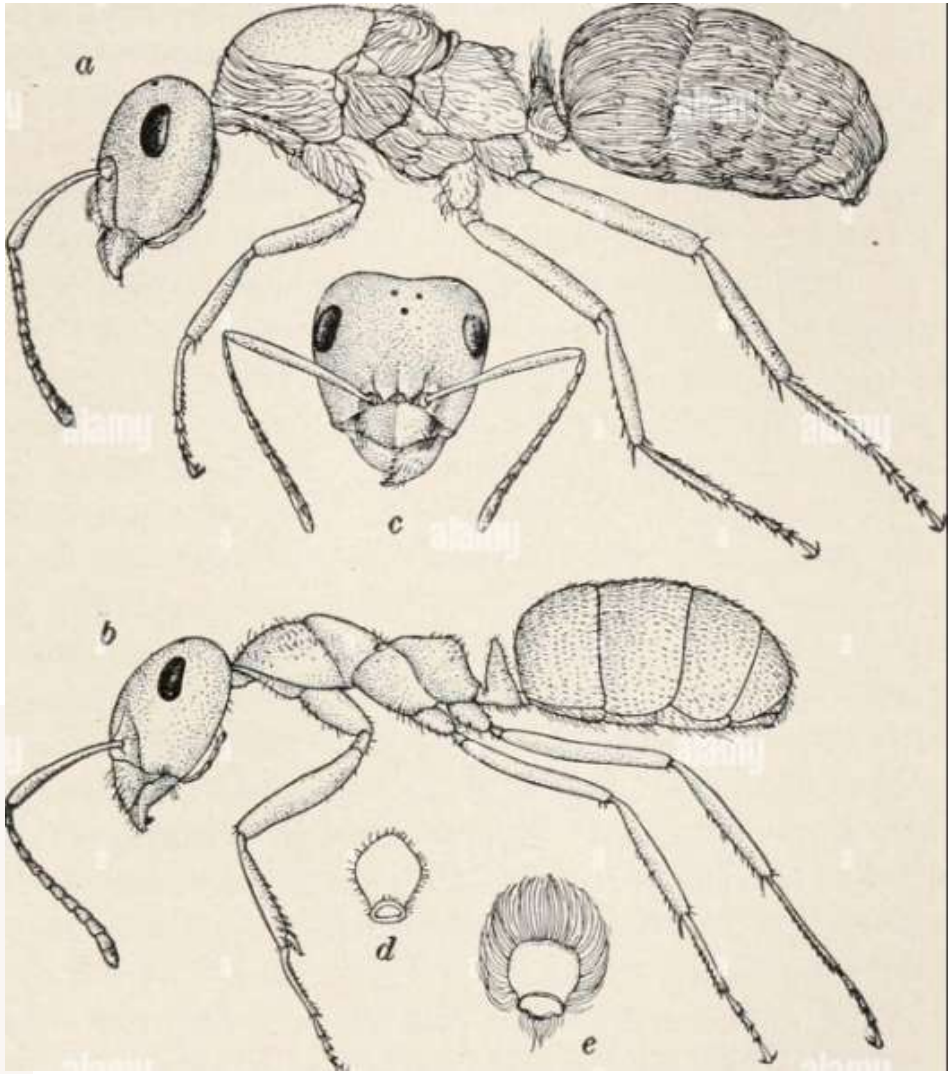
Six legs

Strong jointed limbs

Clear body segmentation







2.Gait Pattern

Tripod gait

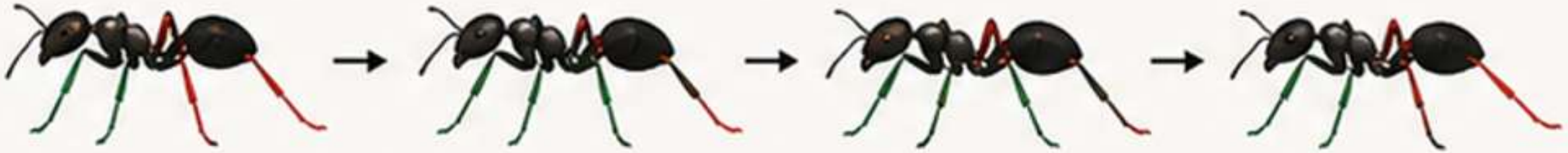
Three legs support the body

Three legs move forward

Support Legs (stance)

Moving Legs (swing)

At any time, three legs are on the ground to support the body, while the other three move forward.

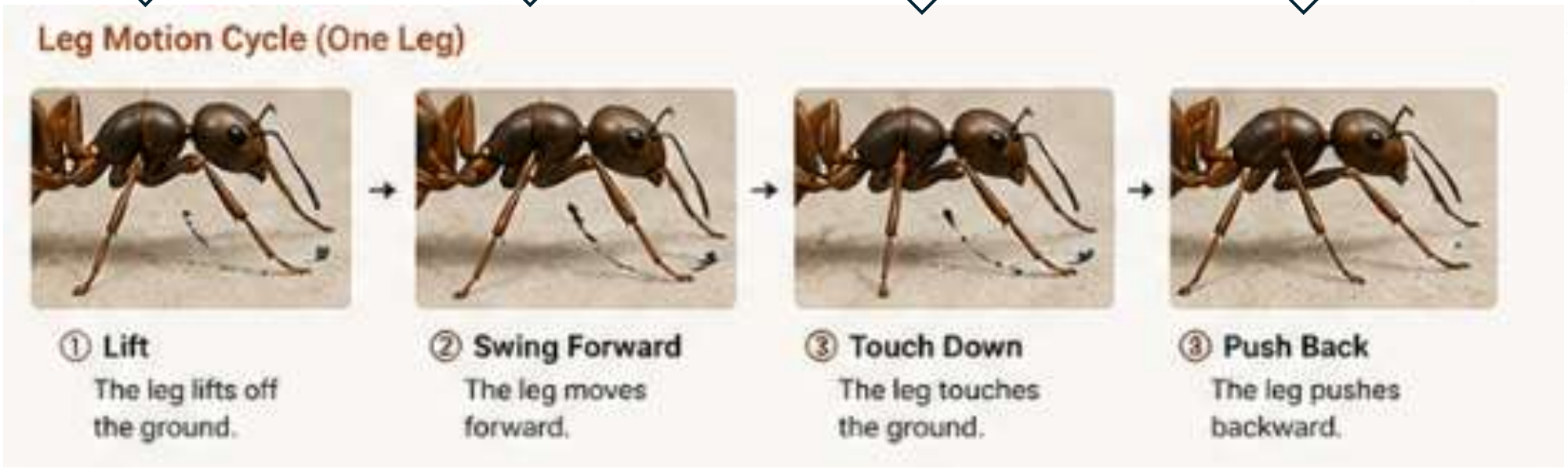


Phase 1 Phase 2 Phase 3 Phase 4

3. Leg Motion

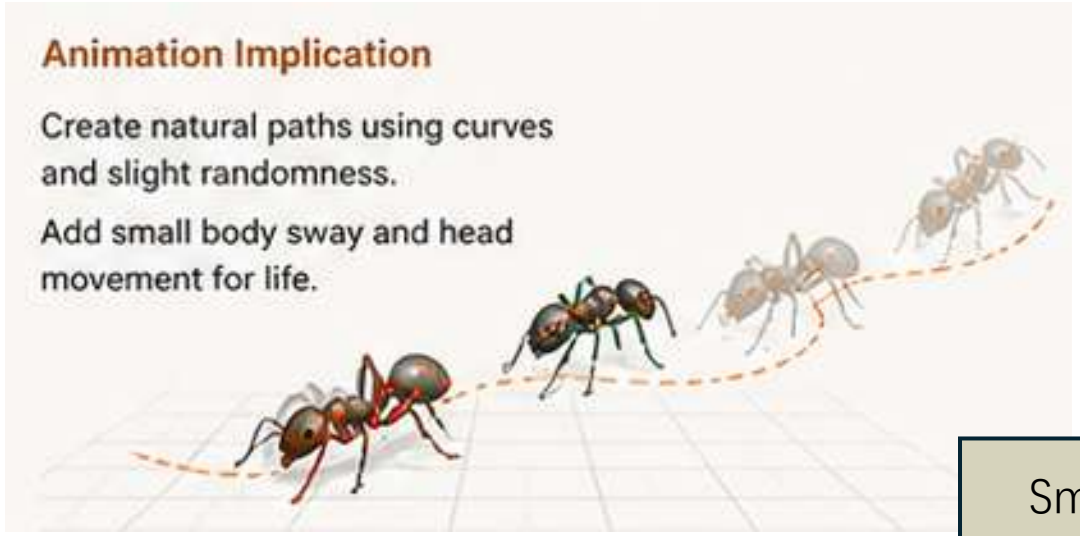
Lift → Swing Forward → Touch Down → Push Back





The left and right legs move at different times. Each pair of legs starts about 2–3 frames after the one in front.

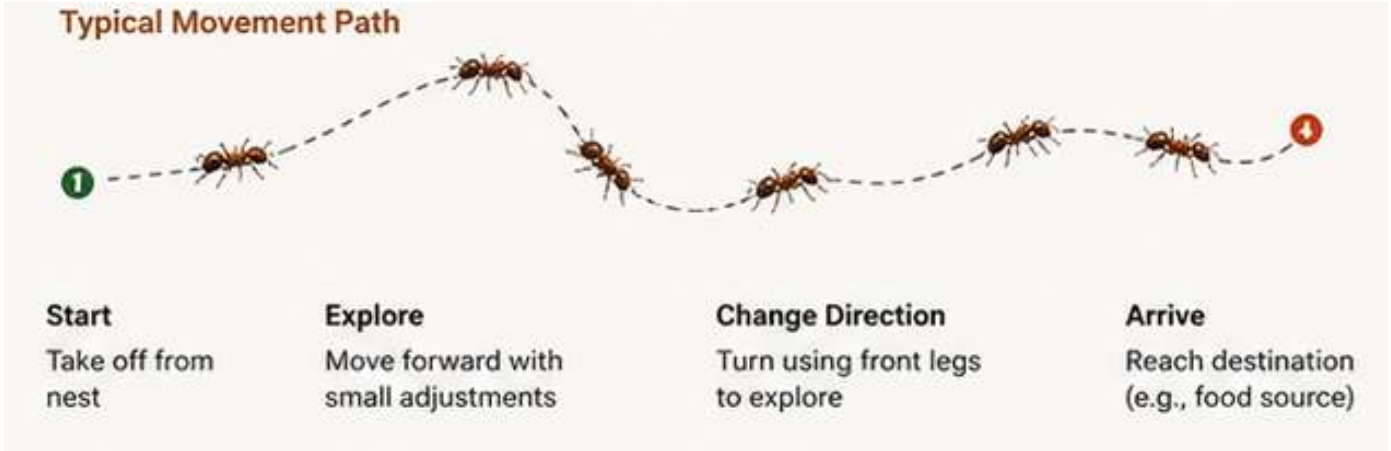
4. Movement Path



Mostly direct and purposeful movement

Slight body sway during walking

Small adjustments when changing direction





Centipede gait

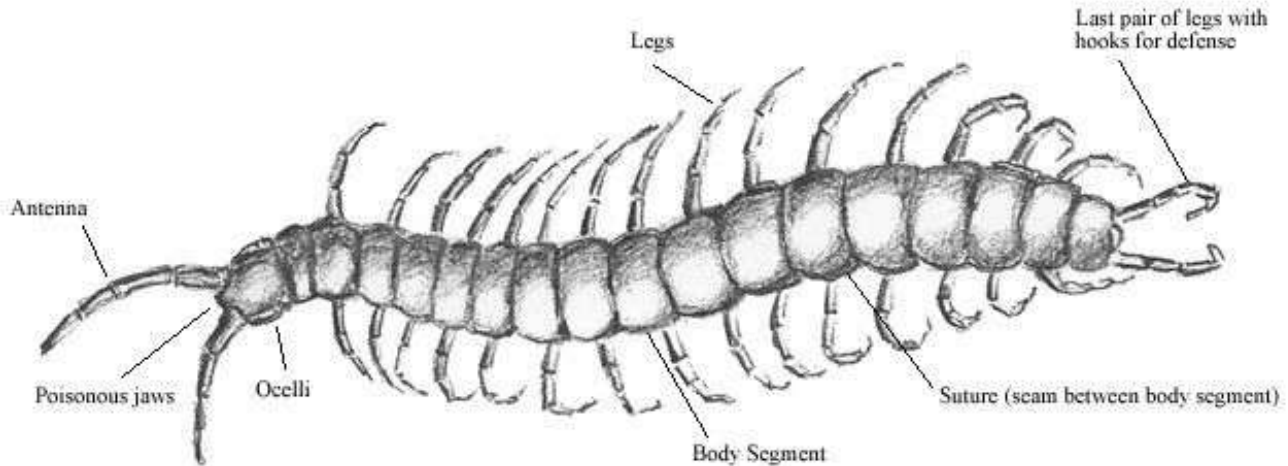
1.Body Structure (Why It Moves This Way ?)

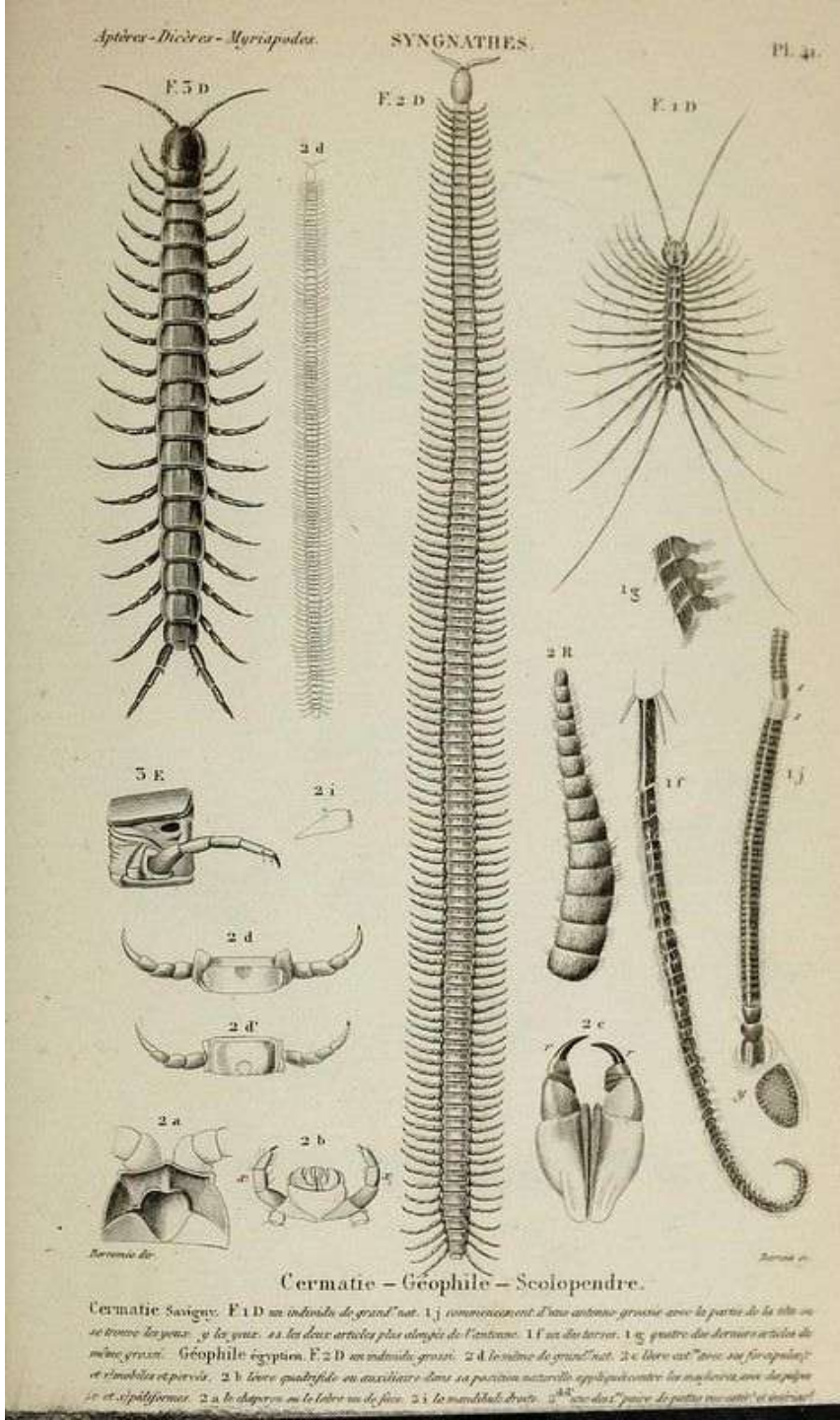
Modular Segments

- The body consists of multiple repeating segments.
- Each segment can independently contribute to overall movement.

Multi-leg Support

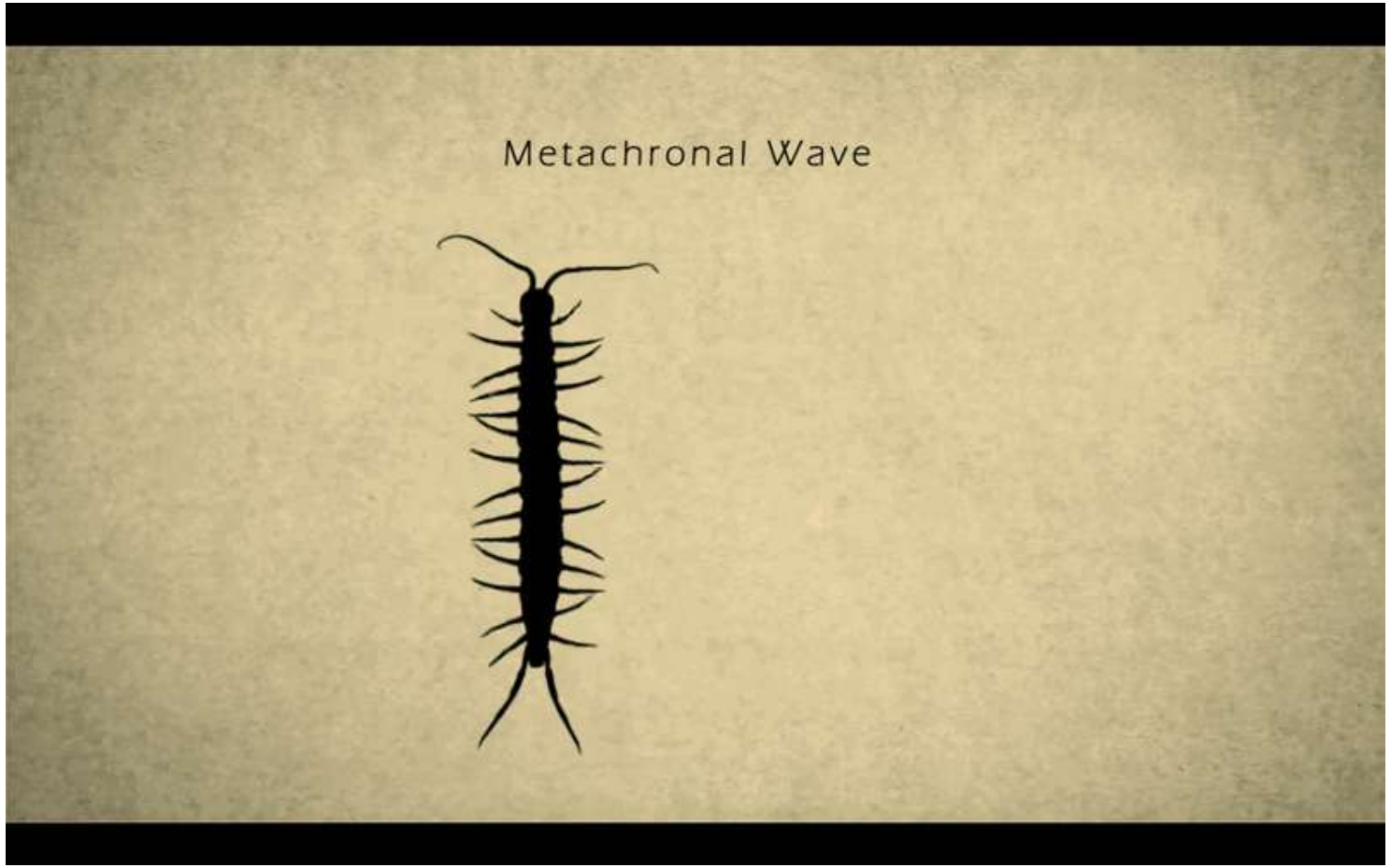
- Each segment is connected to one pair of legs.
- Alternating leg propulsion





2.Gait Pattern

Metachronal Wave gait



(1) Sequential Leg Movement

- Legs move one after another
- Nearby legs move at different times
- The body stays supported

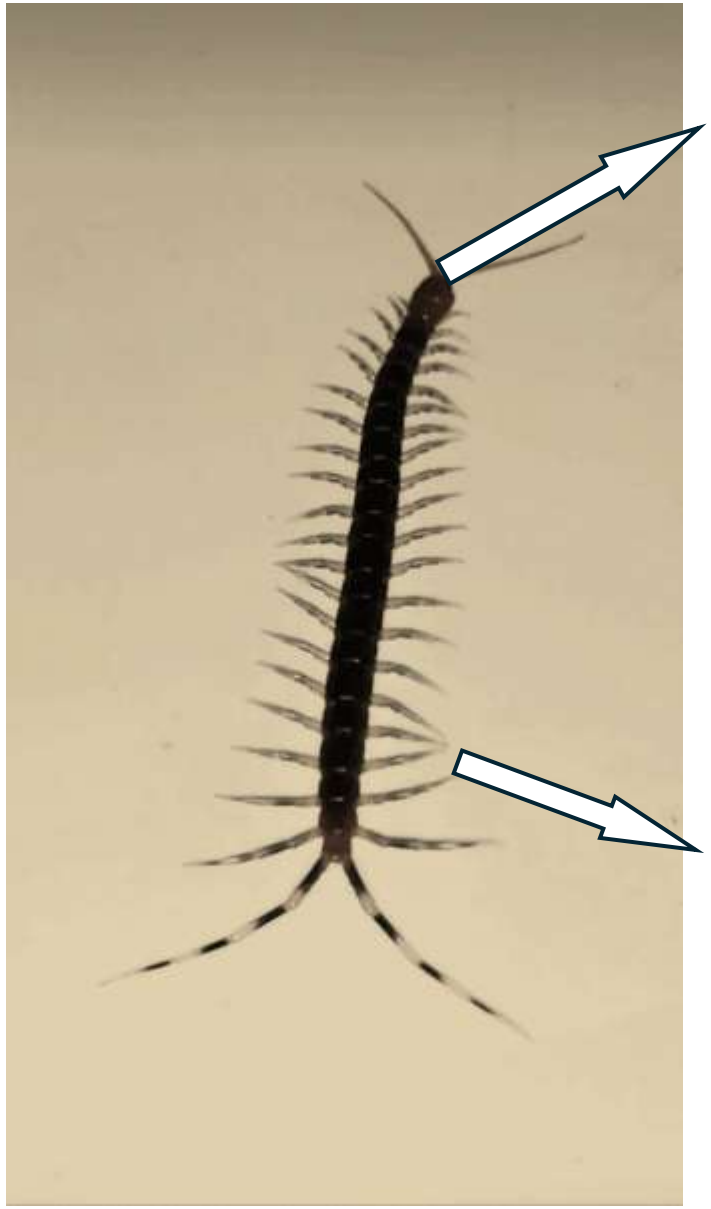
(2) Wave-like Rhythm

- Movement flows like a wave
- The body shows a smooth pattern
- Rhythm helps it move better

(3) Two Movement Modes

- Normal: small and steady movement
- Fast: bigger body movement

3. Body Wave Motion



(1) Bigger movement in the front

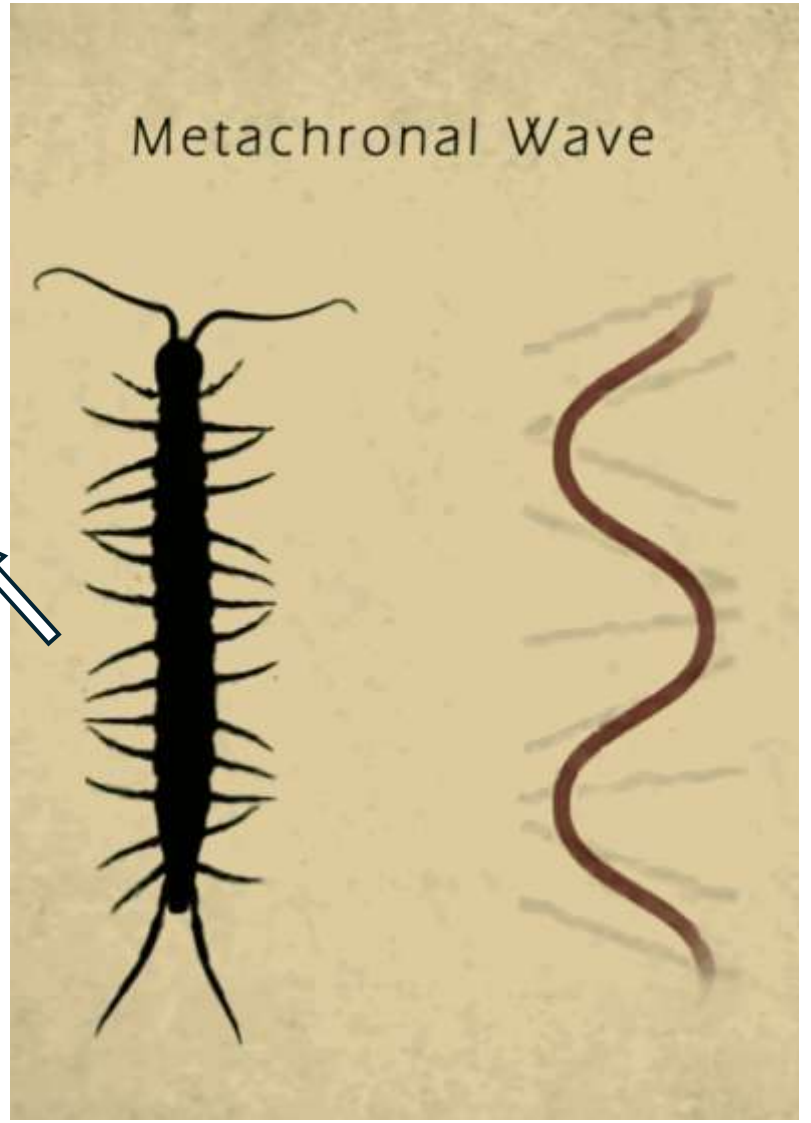
- The front part moves more
- It helps control direction

(3) Delayed movement creates a wave

- Each part moves a bit later
- This creates a wave along the body

(2) Smaller movement in the back

- The back part follows the front
- Movement becomes smaller



4. Leg Motion Cycle



(1)Lift

The leg lifts off the ground

(2) Swing Forward

The leg moves forward

(3) Touch Down

The leg touches the ground

(4) Push Back

The leg pushes backward

- The left and right legs move at different times.
- The left leg stays on the ground while the right leg lifts.
- Each pair of legs starts about 2–3 frames after the one in front.

Caterpillar gait

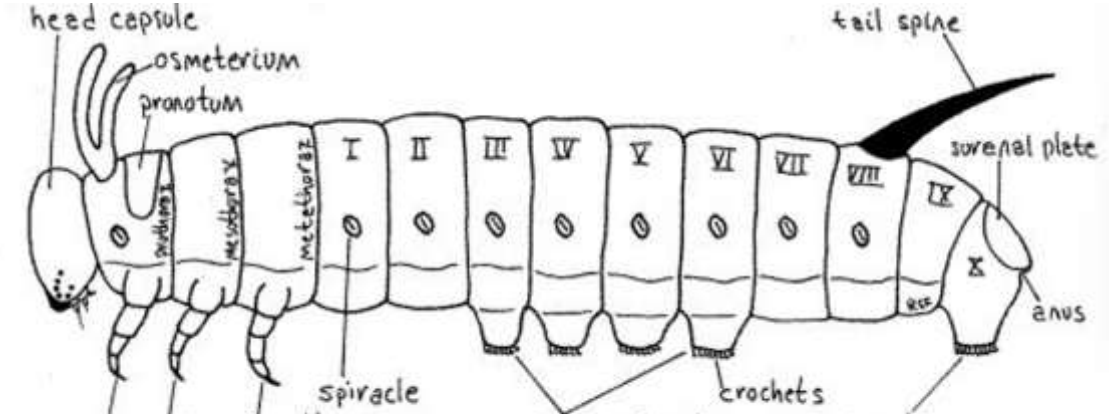
1.Body Structure (Why It Moves This Way ?)

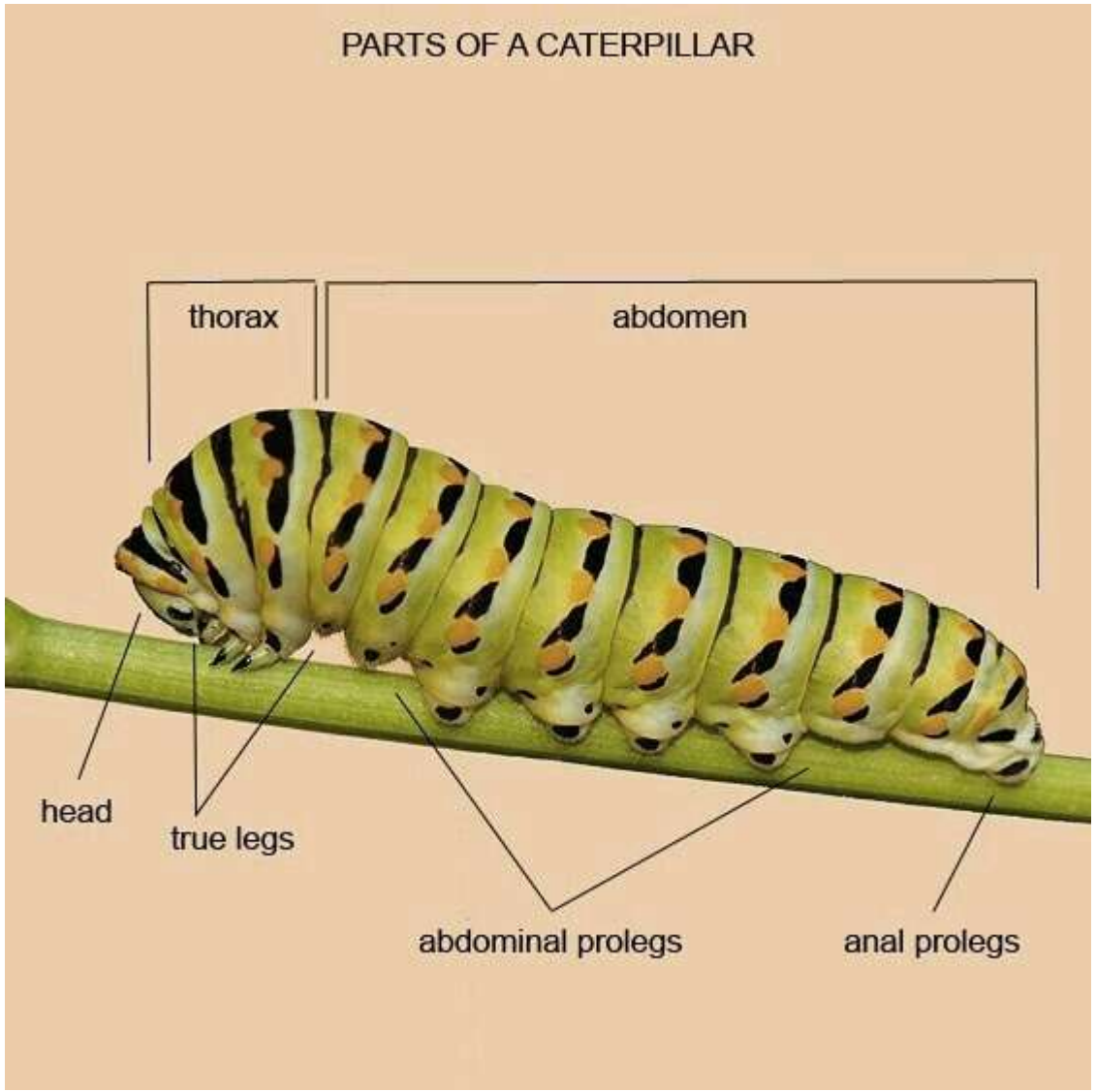
Soft Body

- The body is soft and deformable
- It can compress and stretch

Prolegs and True Legs

- Front legs hold the front in place
- Prolegs grip and release the surface





2.Gait Pattern

Movement mainly comes from the body, not the legs.



(1) Body Compression and Extension

- The body behaves like a soft, fluid-filled tube.
- The body compresses and stretches,This creates movement

(2) Back-to-Front Wave

- The rear moves first
- The wave travels forward

(3) Two Movement Modes

- Typical caterpillars move this way.
- Types with fewer prolegs move in a different way.

3. Body Wave Motion (Typical)

The movement is like a wave traveling forward.



The wave can be seen from both top and side views.

(1) Rear Contracts First

- The rear of the body contracts
- The body becomes shorter and thicker

(2) Bulge Moves Forward

- A bulge forms in the body
- The bulge moves forward

(3) Front Extends

- The front stretches forward
- The body becomes long again



4. Leg Function



- Unlike centipedes, the legs do not alternate.
- Left and right legs move at the same time.
- They act together to hold or release the body.



The legs mainly support and anchor the body, while movement comes from the body.

5. Other Movement Patterns

Looping Movement



(1) Front Grip

- Front legs hold the ground

(2) Pull Back (Loop)

- Rear moves toward the front
- Body forms a loop

(3) Rear Grip

- Rear prolegs grip the ground

(4) Extend Forward

- Front stretches forward
- Body becomes straight again

Bee

1.Body Structure

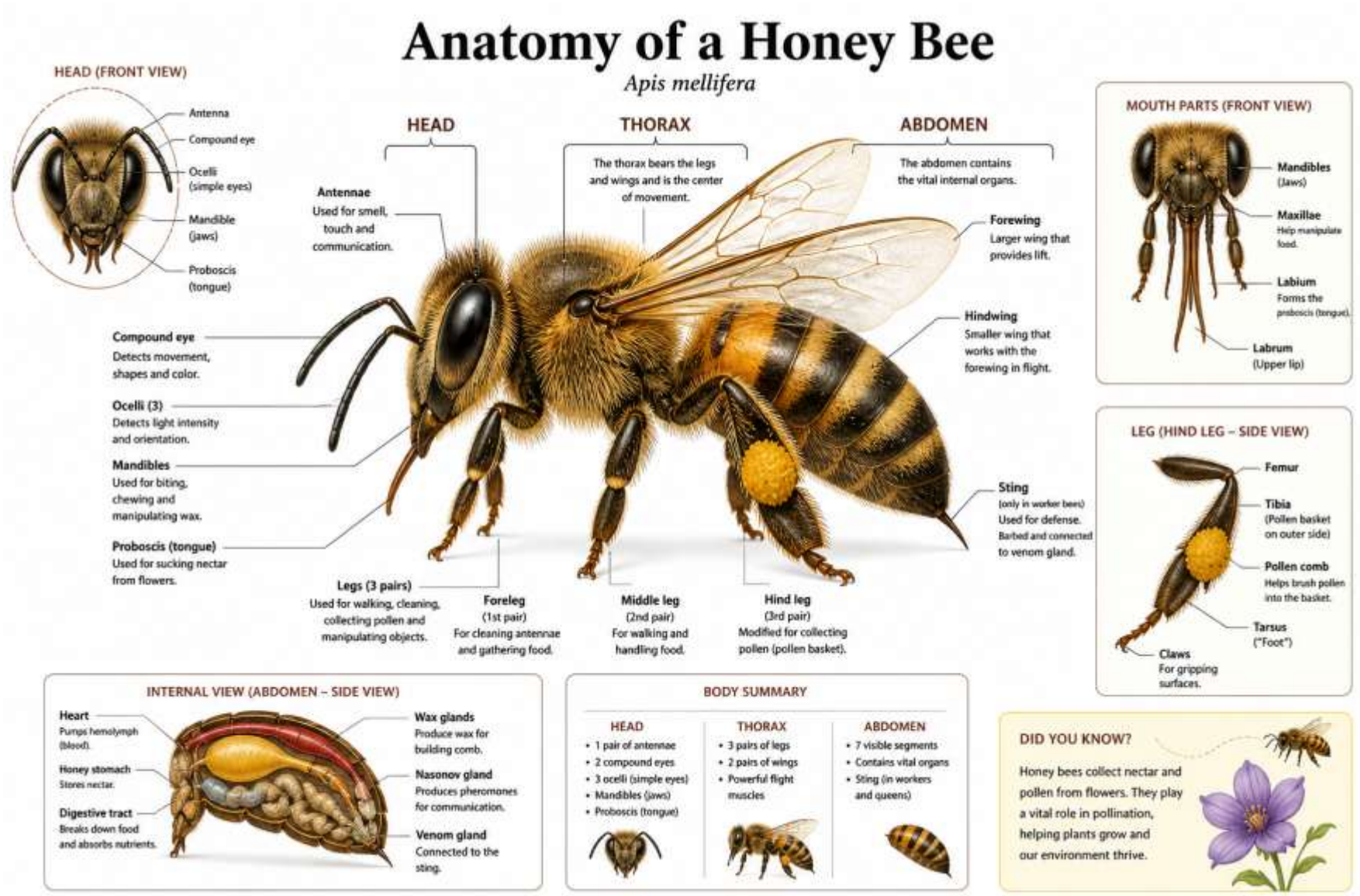
Compact Body

Strong Thorax Muscles

Small Wings Compared with Body

⇩

It needs very fast wing beats to stay in the air.



Bee

2. Flight Pattern



Fast and Stable Flight

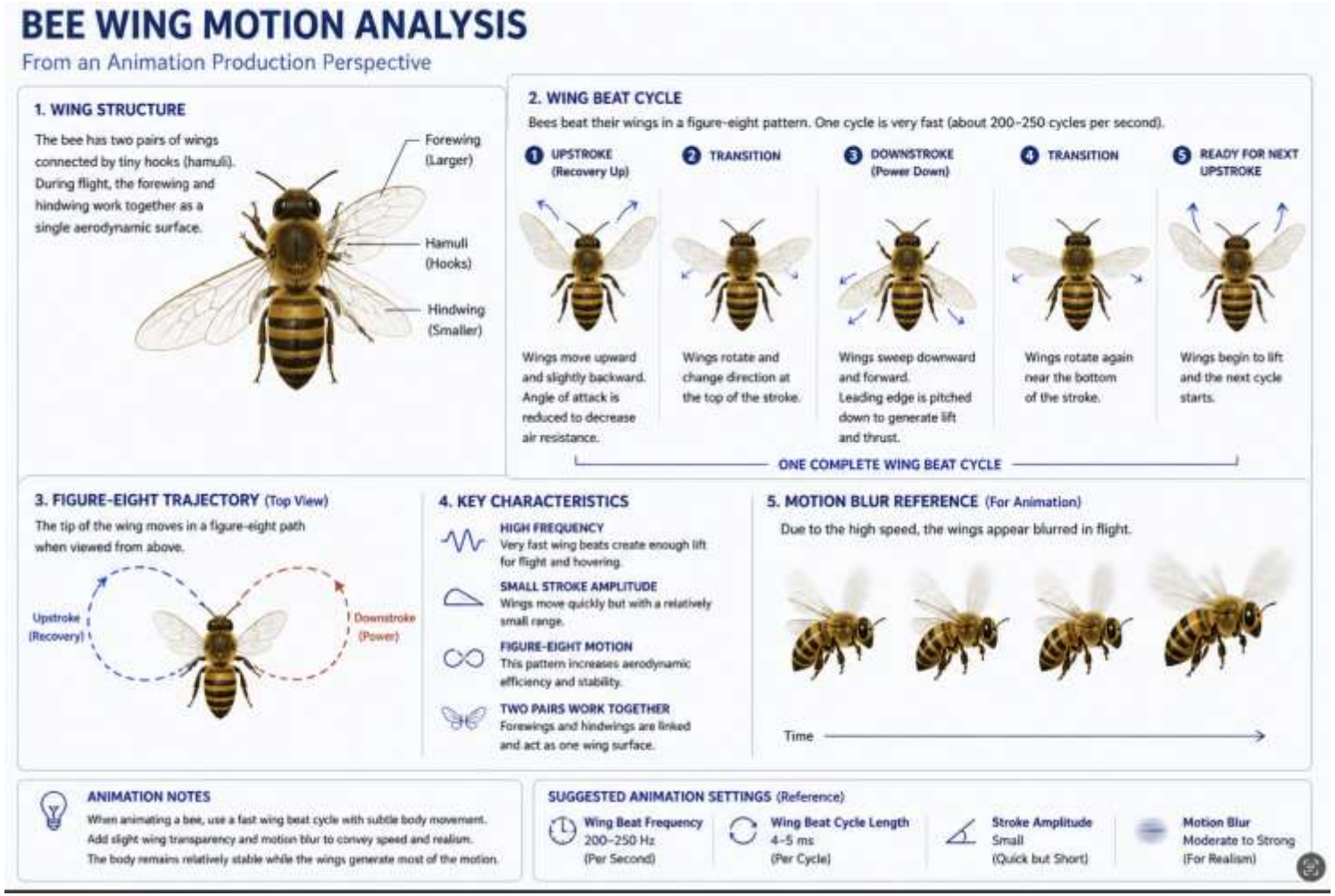
Direct Movement

Hovering Ability

Bees usually fly in a direct and purposeful way.
They can move quickly between flowers.
They can also hover in the air before landing.

Bee

3. Wing Motion



A complete wing beat cycle can be divided into:

Upstroke

The wings lift upward and prepare for the next beat.

Transition

At the highest point, the wings rotate and change direction.

Downstroke

The wings beat downward quickly, generating the main lift and thrust.

Recovery

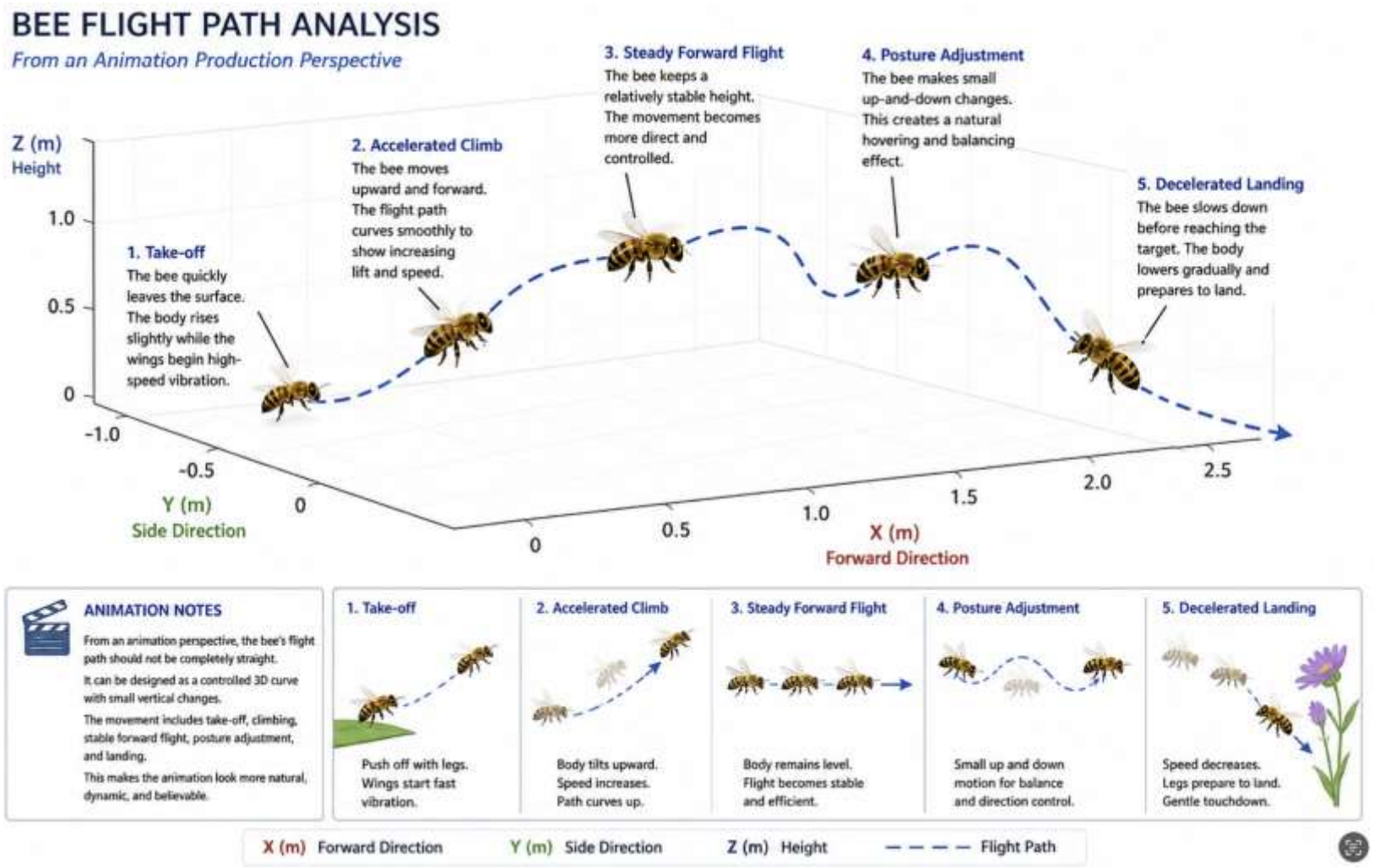
The wings adjust their angle again and enter the next cycle.

Key Words

Fast / High frequency / Small amplitude

Bee

4. Flight Path



The bee's flight path can be animated as a controlled 3D curve. It takes off quickly, climbs upward, flies forward with small height changes, then slows down and lands. These changes make the movement look more natural and believable.

Butterfly

1.Body Structure

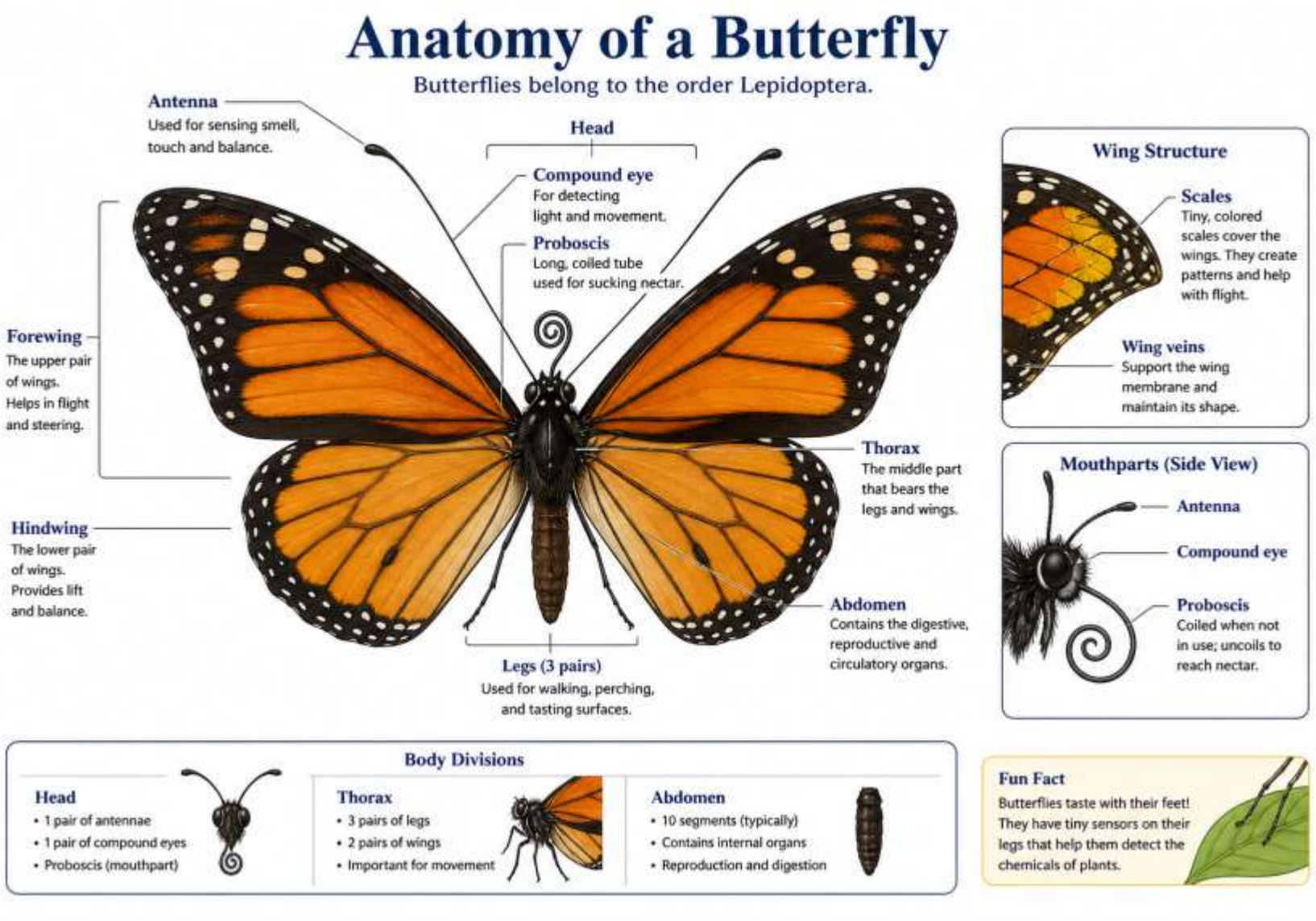
Light and Slim Body

Large Wings

Flexible Wing Surface

⇩

Because of this structure, it can fly with slower but wider wing movements.



Butterfly

2. Flight Pattern



Slow and Floating Flight

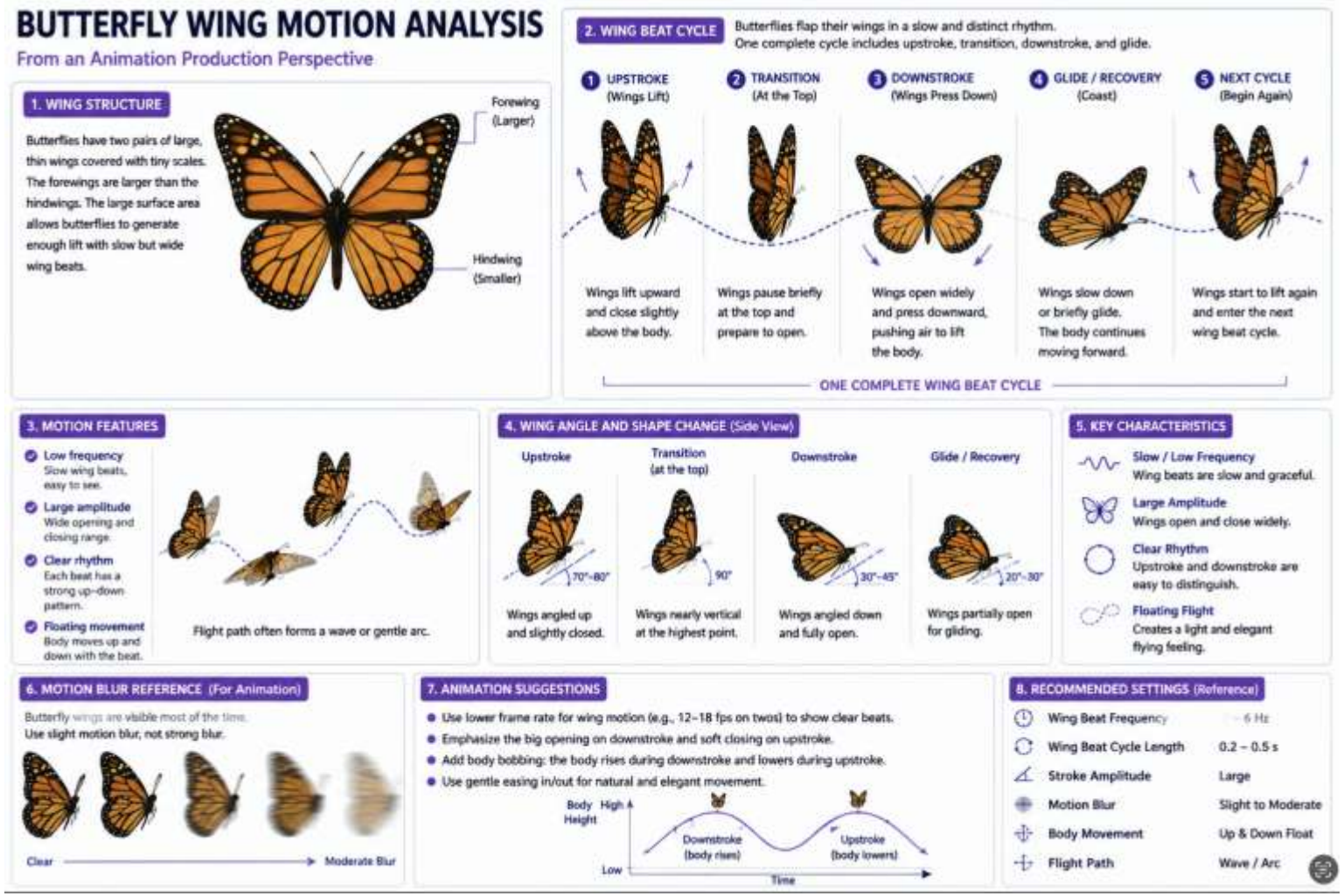
Irregular Movement

Wave-like Path

Butterflies usually fly in a light and floating way.
Their movement is less direct than bees.
The body often moves up and down during flight.

Butterfly

3. Wing Motion



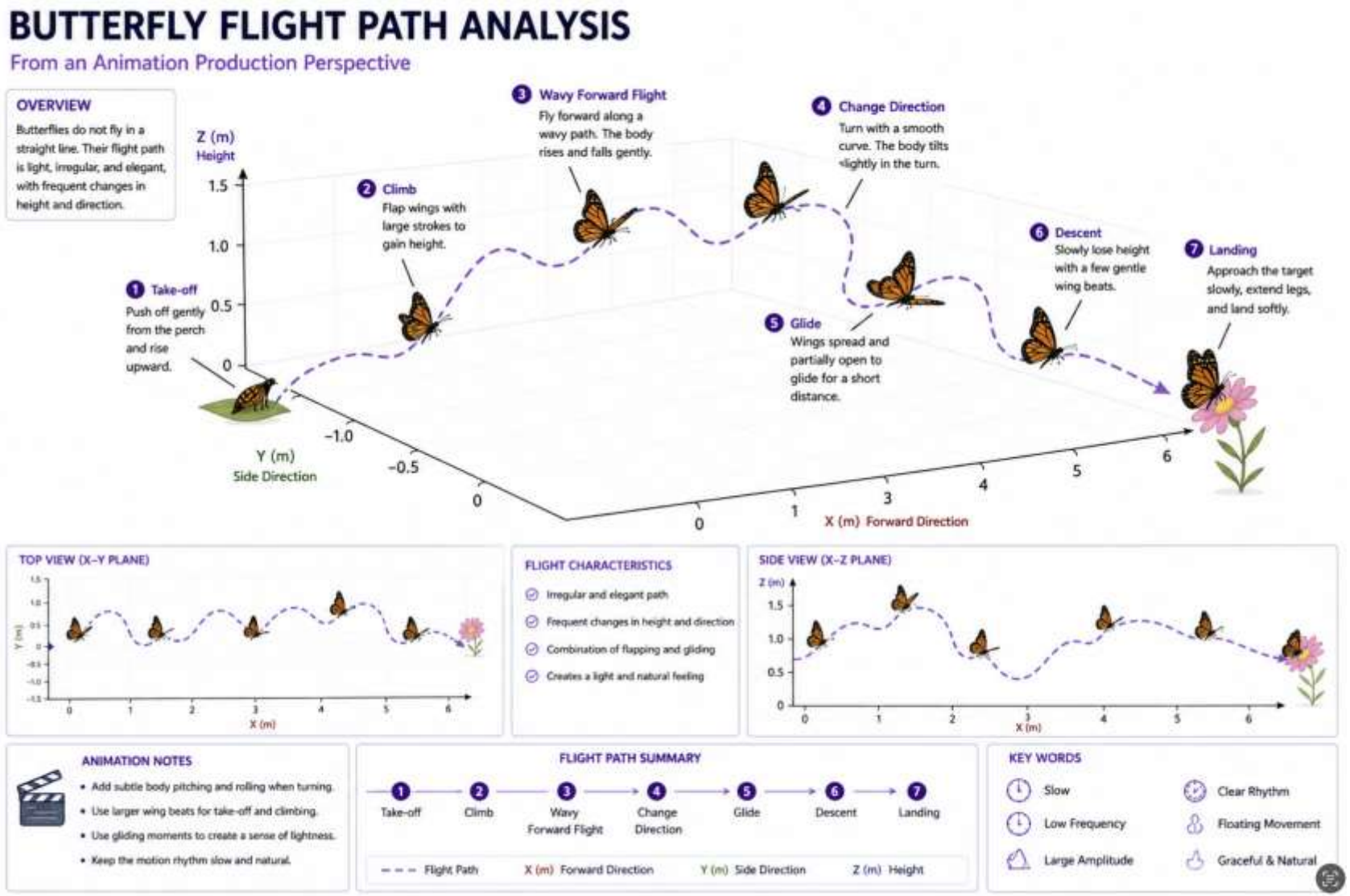
A complete butterfly wing beat cycle can be divided into:
Upstroke
The wings lift upward and close slightly above the body.
Transition
At the highest point, the wings pause briefly and prepare to open again.
Downstroke
The wings open widely and press downward, generating lift and helping the body rise.
Glide / Recovery
The wings slow down or stay partially open, allowing the butterfly to glide briefly before the next beat.

Key Words

Slow / Low frequency / Large amplitude / Clear rhythm / Floating movement

Butterfly

4. Flight Path



The butterfly's flight path can be animated as a soft, wavy 3D curve. It takes off gently, rises with large wing beats, moves forward with clear up-and-down floating motion, then glides briefly before landing softly. These changes make the movement look light, graceful, and natural.

Summary

All arthropod motion can be broken into:

- Body (center of mass, posture)
- Limbs (legs or wings)
- Coordination (timing and gait patterns)
- Secondary motion (small details)

Problem in reality:

- Motion is too fast, complex, and chaotic

Solutions in animation:

- Simplify limb timing
- Enhance rhythmic patterns
- Exaggerate body motion for weight
- Add structured rhythm to flight



