Mechanisms of Timing & Coordination / Response to the Environment

AP Biology - Per. 3
Phototropism in Plants

Tropism is a growth response between a plant and an external stimulus. The stimulus could be weather, touch, time, gravity or light. A positive response is indicated by growth toward a stimulus (such as light) and a negative response is shown by growth away from the stimulus.

Light is a stimulus that plants respond to. This is called phototropism (photo = light). Plants usually display a positive phototropic response to light, which means they grow toward a light source.

Auxin: Any chemical substance that promotes elongation of coleoptiles

- Auxin is a hormone that has a variety of effects, including lateral root formation.

- Major functions: Promotes formation of lateral and adventitious roots, regulates development of fruit, promotes vascular differentiation.

This is an image showing a time-lapse of phototropism.
Photoperiodism

Definitions:

Photoperiodism = The growth, development, and other responses of plants and animals according to the length of day and/or night

Phytochromes = A family of pigment containing proteins that control most photomorphogenic responses in plants

Key Points:

- Photoperiodism can be illustrated by how plants flower and grow at certain times of the day or year through the use of photoreceptors that sense wavelengths of sunlight available during the day and throughout the seasons

- The far-red, and violet-blue regions of the visible light spectrum trigger structural development in plants

- 3 types of plants: Short Day, Long Day, Day and Neutral Plants (can be affected by temperature)

- Photoperiodism is controlled by the Phytochrome system: The inactive form of phytochrome (Pr) is converted to (Pfr) under illumination with red light. Far-red light and darkness convert the molecule back to the inactive form.
Sexual Reproduction

- Not all fungi undergo sexual reproduction
- Isogamous reproduction creates recombinant spores
  - new allele frequencies
  - essential for genetic diversity
- Compatible mates have hyphal tips that grow towards one another, forming a progametangia
- Altered form of meiosis
  - Nuclear membrane remains intact; diploid nucleus splits along the middle
  - Crossing over still occurs
- Occurs when food is scarce or when are stressed
  - Requires more energy expenditure
Asexual Reproduction

- Perfect fungi reproduce both sexually and asexually, while imperfect fungi reproduce only asexually.
- All offspring are genetically identical to the parent.
- 3 Main Methods
  - 1) Budding - A form of asexual reproduction in which a new individual develops from some generative anatomical point of the parent organism.
  - 2) Fragmentation - The simplest method of reproduction of fungi is by fragmentation of the thallus, the body of a fungus.
  - 3) Asexual Spores - Two main types: Sporangiospores and Candida.
Fruiting bodies are structures that are formed in response to the environment. They sometimes contain spores and are therefore sometimes reproductive structures. But they are also formed in times of distress such as, starvation in certain bacterial colonies, temperature changes, and increase in humidity.
**BACTERIA**

- Example of cell differentiation in bacteria in response to changes in the environment is the formation of a **heat and desiccation-resistant cell morphology** (spores and cysts).
- Bacteria **congregate** to lyse cells to protect themselves.
- Spore formation is generally induced by nutrient depletion.
- Spores are generally:
  - less metabolically active than vegetative cells
  - more resistant to chemical and physical stresses than vegetative cells
  - can survive extended periods of starvation

**SLIME MOLDS**

- When organisms become starved of their prey, **phagocytosing vegetative phase** occurs
  - a tower of cells forms, which develops into fruiting body
- Spore cells from the fruiting body-tough cell wall, allowing **resistance**: temperature extremes, desiccation & digestion/ are dispersed ready to start a new life cycle
- The “slugs” (tower of cells that tips over) move towards **attractants** (light, heat and humidity) - leaves behind slimy trail from its extracellular cellulose matrix.
  - Relocation allows formation of fruiting body & spore dispersal in a more favourable location

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**FUNGI**

- Fruiting body is part of the sexual phase of a fungal life cycle & the rest of the life cycle is vegetative mycelial growth and asexual spore production
- **Optimal temperature** for fruiting body formation = 25 degrees Celcius
- Fruiting bodies are sometimes called **mushrooms** or toadstools. These all generally have the same job; they all make spores.
- These **spores** are basically seeds that when blown around they can grow new fungi. The fruit bodies are the fruits of the fungus - just like apples are the fruits of the apple tree.

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Chemotaxis in Bacteria

Chemotaxis is a mechanism by which bacteria efficiently and rapidly respond to changes in the chemical composition of their environment, approaching chemically favorable environments and avoiding unfavorable ones.

- This behavior is achieved by incorporating signals received from receptors that sense the chemicals in the environment and changing the direction of the flagellum accordingly.

Prokaryotes that exhibit chemotaxis change their movement pattern in response to chemicals.

- They may move towards nutrients or oxygen (positive chemotaxis) or away from toxic substances (negative chemotaxis).
A test conducted by the Princeton University scientists in 2003 showed that E.Coli exhibits positive chemotaxis towards other members of their species enabling the formation of colonies.
Taxis

- Response to environmental stimulus in the form of movement.
- It is what we think of when we think of movement.
- Some of the most popular stimuli include food, light, emotions.
- Can be positive or negative.
- Ex) Fruit flies will be attracted to light and food. These are considered to be positive stimuli. Fruit flies will avoid the darkness.
Kinesis

- Changes in intensity of activity level in animals that are dependent on stimulus intensity.
- Does not cause the animal to move in a specific direction.
- It is neither positive nor negative
- Ex) When light is shown on cockroaches they will neither move towards or away from the stimuli, they will move randomly in different directions.
Overview of Pheromones

- **Pheromone**: a released or excreted chemical factor that triggers a social response in members of the same species

- There are **alarm pheromones**, **food trail pheromones**, **sex pheromones**, and many others that affect behavior or physiology of the organism and its related species

- These chemical messengers are transported outside of the body and affect **neurocircuits**, including the nervous system with hormone or cytokine regulated physiological changes, inflammatory signaling, immune system changes and/or behavioral change in the recipient
Main Types of Pheromones

**Aggregation**- common among insects, these are responsible for mate selection, used as sex attractants (sometimes for both sexes) to attract sexes to the “calling site”

**Alarm**- alarm pheromones in insects induce a flight or aggression response, while in plants, induces tannin production in nearby plants after being grazed upon by an herbivore

**Releaser**- these pheromones can be slowly deposited or vaporized, they are responsible for signaling to species in the presence of the “territory” (Ex: domestic rabbits and mammary pheromones for nursing)

**Signal**- primer pheromones elicit a change in the endocrine system for the animal receiving it (Ex: female rats mature faster near adult male rats)
Shivering

- A warm blooded organisms response to early hypothermia or simply feeling cold
- Muscles around the vital organs start to shake, creating warmth by expanding energy
- This raises the body temperature of the organism to feel cold until it reaches the target set point
- Used by body to maintain homeostasis
Sweating

-a bodily function that helps regulate your body temperature
-aka perspiration
-release of a salt-based fluid from your sweat glands
-can also be caused by emotional state
-most common areas of sweating on the body include:
  - armpits
  - face
  - palms of the hands
  - soles of the feet
-Eccrine sweat glands are located all over your body and produce a lightweight, odorless sweat.
-sweat is released through ducts in your skin. It moistens the surface of your body and cools you down as it evaporates.
Hibernation, Estivation, and Migration

- **Hibernation:**
  a state of inactivity and metabolic depression in endotherms. Hibernation refers to a season of heterothermy that is characterized by low body temperature, slow breathing and heart rate, and low metabolic rate.

- **Estivation:**
  (zoology) prolonged torpor or dormancy of an animal during a hot or dry period.
  (botany) the arrangement of petals and sepals in a flower bud before it opens.

- **Migration:**
  seasonal movement of animals from one region to another (ex: birds), movement from one part of something to another (ex: plant cells).
Responses to the Climate

Hibernation
- When the winter arrives, hibernation allows animals to save energy and survive despite lack of sustenance.
- In preparation for this, they eat extra which they store as body fat for their bodies to turn into molecular energy during the long months of winter. The excess body fat also keeps their body temperatures stable.

Estivation
- Whereas hibernation is in response to the cold, estivation is in response to the heat. Although it can also be in response to water shortage.
- Animals that depend on water, such as crustaceans and crocodilians, burrow down into the soft, wet mud during the dry seasons.

Migration
- Unlike hibernation and estivation where animals buckle down for the weather, animals that practice migration leave in search for their preferred weather conditions.
- Many flocks of hundreds of thousands of birds migrate every year from the cold of their current home to the warmth of their next one.
**Diurnal / Nocturnal**

**Diurnal** - of or during the day; occurring daily
**Nocturnal** - of or during the night; occurring nightly

Sleep/Wake Cycles:
Sleep regulated by 2 body systems:
- sleep/wake homeostasis
  → tells us to sleep after we’ve been awake for a long time
- Circadian biological clock
  → regulates timing periods of sleepiness and wake

Strongest sleep drive is between 2-4 am and 1-3 pm.

Claire Bang and Philip Witcraft
Period 3

NREM and REM cycles
-NREM stage 1
→ Stage in between.
→ Muscles are active, eyes roll
  (sometimes open and close)

-NREM stage 2
→ Person is harder to waken
→ sometimes waken suddenly by sleep spindles

-NREM stage 3
→ person no longer responding to environment

-REM
→ muscles are paralyzed
→ you’re basically out.
Examples diurnal:
- humans
- ostriches
- angiosperm species of flowers

Examples of nocturnals
- cats
- koalas

Perks of being nocturnal
- harder to detect
- less competition (with diurnal species)

Best of both worlds = Crepuscular
- animals active at dusk and dawn
- prey happens to be more active
- temperatures cooler
- ex. bats

Diurnals vs. Nocturnals?
- According to our natural Circadian rhythm, humans are DIURNAL.
- Some humans are NOCTURNAL because they have the same schedule but just during the night.

Possible “solutions”
- strict schedules
- light therapy → tricking body to wake up
- sleeping pills, vitamins, treatments → ex. B12, melatonin

Nocturnal people we know:
- firemen
- paramedics
- doctors
- bakers
- 24-hour convenience store keepers
Circadian Rhythm

- Circadian Rhythm: any biological process that displays an endogenous entrainable oscillation of about 24 hours
  - rhythm driven by circadian clock
  - observed in plants, animals, fungi, and cyanobacteria
  - adjusted to the local environment by external cues called zeitgebers, commonly the most important of which is daylight
    - zeitgebers: entrains, or synchronizes, an organism's biological rhythms

- Present in:
  - sleeping patterns
  - feeding patterns
  - core body temperature
  - brain wave activity
  - hormone production
  - cell regeneration
  - photoperiodism
    - has to do with jet lag
  - enzyme activity
  - tells plant what season it is
  - best time for budding and pollination
  - leaf movement
  - germination
  - photosynthetic activity
  - fragrance emission
Jet Lag

- Symptoms increase in severity the more time zones are crossed
- Traveling across many time zones = exposure to daylight and darkness at irregular intervals
  - Causes body clock to be out of sync, disrupting natural circadian (sleep-wake) rhythm
- Theory: Possibly related to changes on oxygen levels
  - Air pressure inside airplane is lower than it is at sea level
    - Decreased oxygen = less diffusion = less oxygen for tissues of the body, especially brain
- Theory out of University of Washington:
  - Disruption of neurons in suprachiasmatic nucleus located “below the hypothalamus at the base of the brain.”
  - 2 Groups of neurons:
    - (1) for deep sleep - tied to light-dark cycles and adjusts within a couple of days.
    - (1) for rapid eye movement (REM) sleep - tied to light-sensitive dorsal neurons and takes approximately a week or more to resync. Until then, it follows its natural clock.
  - When these clocks are out of sync, REM does not occur in a normal progression after deep sleep.

Fun facts:
- The older a person is, the stronger their symptoms will be.
- Symptoms increase in severity the more time zones are crossed.