8.1 Internal Fertilization

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Learning goals
• Internal fertilization- cause
• Internal fertilization- function

Slide 2

What is internal fertilization?

- Sperm placed inside female organ (implies more complex instinctive behavior & learning mechanisms)
- Diverse anatomical mechanisms- divergence (Halliday 1994:23)
  - Penis- mammals
  - Pedipalps- spider
  - Hemipens- snake
  - Cloacal contact- birds
  - Spermatophore- salamander/insects

Slide 3

Hypotheses- Function of internal fertilization

- H1: when seasonal resources are clumped, the optimal timing for birthing (shelter/food for calf) may be different than the optimal time for mating (when males find females on clumped resources)
- H2: synchronize male:female behavior (ovulation & fertilization)
- H3: extra care for a few large young (better able to survive predictable environmental challenges compared to many small young)
- H4: paternity assurance for males (less likely to care for young not their own)
Slide 4

**H1. Optimal timing for birthing...**

*Source: “Arriving” Trials of Life*

Video source: “Arriving” Trials of Life (antelope.avi)

Slide 5

**H1 (cont’d): ….influences timing & complexity of mating**

*Source: “Courting” Trials of Life*

Video source: “Courting” Trials of Life (topi.avi)

Slide 6

**Polygamous Ungulates**

- **PC: Mechanisms**
  - Female provides all the care
  - Males compete for copulations
- **UF: Functions**
  - Rainy season migration - good food
  - Large young - escape predators
  - Mate guarding
Slide 7

**H2: Synchronization: ovulation & fertilization**

Source: “Courting” Trials of Life

Slide 8

**H2: Polygamous rodents**

- **PC: Mechanisms**
  - Female scent attracts male
  - After birth, female ovulates (3 hr)
  - Multiple copulations (male leaves, female nurses)

- **UF: Functions**
  - Short interbirth interval
  - Male mate guarding

Slide 9

**PC Internal Fertilization- birds**

Source: “Courting” Trials of Life
Blue footed booby - background info

Source: “Courting” Trials of Life (booby.avi)

PC: displays of Blue-footed Booby

PC: Mechanisms
- Instinctive signals: lift blue feet (species-specific “identity badge”)
- Bonding by head tossing & stick placing (no functional nest)
- Mount, brief cloacal contact near the “nest” site

UF: Functions
- In a nesting area with mixed species, individuals choose mates of the same species (blue- …not red-footed boobies)
- Bi-parental defense and care of nestlings is more successful in a colony; quality of nest does not enhance nestling survival
- Male paternity certainty- those that raised their own offspring...

Video source: “Arriving” Trials of life (hangfly.avi)
**Insects - “nuptial gift”**

- **PC: Mechanisms**
  - Male Hanging Fly catches insect “gift”
  - Female takes and eats prey
  - Male clasps & copulates 20 min
  - Struggle for remaining prey
- **UF: Functions**
  - Female nutrition => better eggs
  - Male safety & mate guarding

**SUMMARY: function (example)**

- **H1:** Optimal time for birthing influences optimal timing for breeding (e.g. complex courtship of aseasonal antelope)
- **H2:** Synchronize ovulation & fertilization (e.g. hamster)
- **H3:** Extra care for a few large young (e.g. blue-footed booby)
- **H4:** Paternity assurance for males (e.g. booby, hanging fly)

**Action Items - Internal fertilization**

- Prepare answers for
  - Q8.1. Mechanism of internal fertilization...
  - Q8.2. Function of internal fertilization, alternative hypotheses...
- Some recommended searches on Web of Science:
  - “nuptial feeding” AND “scorpionflies”
  - “topi” AND “Animal Behavior”
- Recommended searches on scholar.google.com
  - “hamster mating” (since 2000)
  - “blue-footed booby”
- Dialogue
  - Volunteer to chat on Q8.1, Q8.2
  - Post examples/sources to Blog3 Unit 8
8.2 External Fertilization

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Learning Goals
• External fertilization - cause
• External fertilization - function

What is external fertilization?

- Eggs & sperm both released outside bodies
  - Fertilization occurs in water
  - More instinctive than learned
- Typical of "ancient" species
- Also "modern" adaptations to
  - Unpredictable land environments (treefrog)
  - Predictable predation (fish)

Video source: “Arriving” Trials of Life (urchin.avi)
**Slide 4**

**UF: Adaptation to ocean conditions**

- **PC: Mechanisms**
  - Males release sperm into the ocean
  - Females release eggs (millions)
- **UF: Functions**
  - Recombinant DNA - diversity
  - Planktivore predator swamping
  - Lottery analogy - chance & patchy environments

**Lottery analogy**
- Many produced
- Many die in poor conditions
- A fit hit the “lucky jackpot” of good conditions

**Slide 5**

**UF: Predator swamping - herring**

Video source: “Arriving” Trials of Life (herring.avi)

**Slide 6**

**UF: Adaptation to coastal conditions**

- **PC: Mechanisms**
  - Schooling fish move to coast
  - Sperm & eggs released at same time
- **UF: Functions**
  - Recombinant DNA
  - Lottery analogy
  - Widespread dispersal
  - Shorebird predator swamping
Slide 7

PC Synchronization - land crabs

Source: “Arriving” Trials of Life

Video source: “Arriving” Trials of Life (Xmascrab.avi)

Slide 8

UF: Adaptation to islands

- PC: Mechanisms
  - Synchronized by moon & high tide
  - Land crabs - move to ocean
  - Release eggs & sperm into water
- UF: Functions
  - Recombination of DNA
  - Lottery analogy
  - Widespread dispersal between islands

Video source: “Arriving” Trials of Life (treefrog.avi)

Slide 9

PC: Parental care - Trinidad treefrog

Source: “Arriving” Trials of Life

Asian species

Video source: “Arriving” Trials of Life (Xmascrab.avi)
UF: Adaptation to dry season conditions

PC: Mechanisms
- Male treefrog holds female in amplexus
- Female lays egg in curled leaf
- Male releases sperm
- After eggs hatch, tadpoles drop in pond

UF: Functions
- Recombinant DNA
- Mate guarding/ egg protection
- Optimal conditions related to seasonal rain

UF: Adaptation to predictable predation

PC: Mechanisms
- Male nest digging & guarding
- Female spawns on rock; male fertilizes
- Transfer hatchlings to nest; oxygenation
- Swimming fry feed on mucous

UF: Functions
- Optimal conditions for fry- stable environment
- Nest guarding- paternity assurance
- Reduce risk of predation on fry

Video source: “Arriving” Trials of Life (cichlid.avi)
SUMMARY: External fertilization- functions

- **H1**: adaptation to marine environment
  - ancestral trait – asynchronous release of sperm & eggs
  - e.g. sea urchin

- **H2**: adaptation to predictable predation at land/water interface
  - derived trait – synchronized by tide &/or moon
  - e.g., herring, Christmas Island land crab

- **H3**: adaptation to predation in ephemeral ponds that dry up
  - Derived trait- parental construction of leaf nest
  - e.g. Trinidad treefrog

- **H4**: adaptation to predictable predation on eggs & hatchlings
  - derived traits – nest construction, guarding and feeding
  - e.g. midas cichlid

**Learning Goals**
- External fertilization- cause
- External fertilization- function

**Action Items- External fertilization**

- Prepare answers for
  - Q8.3. Mechanism of external fertilization…
  - Q8.4. Function of external fertilization…

- Some recommended searches on Web of Science:
  - “treefrog” AND “Ryan, M”

- Recommended searches on scholar.google.com
  - “external fertilization”

- Dialogue
  - Volunteer to chat on Q8.3, Q8.4
  - Post examples/sources to Blog3 Unit 8
Learning, Discovering and Sharing Knowledge

8.3 Asexual/ Hermaphroditic

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Learning goals
• Asexual strategies- function
• Asexual strategies- evolution

Slide 2

What are alternatives to bisexual reproduction?

- Asexual
  - No recombination of DNA
  - Clones- exact copies

- Hermaphroditic
  - Each individual produces both sperm and eggs- recombinant DNA
  - Both male & female behavior (simultaneous or sequential)

Slide 3

PC: Budding mechanism- sea louse

Source: “Courting” Trials of Life (sealouse.avi)
PC: Other species - asexual

AQUATIC
- Sea louse
- Hydra
- Daphnia
- Jellyfish \((Aurelia\ labiata)\)
- Starfish (budding)
- Fire worms (budding)
- Cleaner shrimp (sequential)

TERRESTRIAL
- Aphids (conditional)
- Snails (simultaneous)
- Termites (queens clone themselves)
- Whip-tailed lizards (conditional)

Parthenogenesis: over 80 vertebrate taxa (fish, amphibians & reptiles)

(Neaves & Baumann 2011)

PC: hermaphroditic - giant clam

Source: “Courting” Trials of Life
clam.avi

UF: Function of asexual reproduction

- H1: Rapid reproduction in short-term optimal conditions
  - ocean, pond, plant (at the beginning of the growing season)
  - e.g. aphid
- H2: Reproduction not dependent on presence of opposite sex
  - patchy habitat, small populations
  - e.g. giant clam, whip-tailed lizard
UE: phylogenetic history- asexual strategies

- **H1:** One-celled organisms
  - Ancestral – asexual species evolved in ocean
  - Derived- marine asexual species adapted to freshwater ponds
  - Derived- conditional switch from asexual to sexual
- **H2:** Multiple-celled organisms
  - Ancestral- bisexual reproduction
  - Derived- parthenogenesis

SUMMARY: alternatives to bisexual strategies

- **Function**
  - **H1:** rapid reproduction in short term optimal conditions (e.g. hydra, daphnia, aphids)
  - **H2:** reproduction in patchy, small populations (giant clam)
- **Evolution**
  - **H1:** 1-celled oceanic ancestor=> freshwater ponds
  - **H2:** multi-celled bisexual ancestor=> parthenogenesis

Learning goals
• Asexual strategies- function
• Asexual strategies- evolution

Action Items- Asexual/hermaphroditic

- Prepare answers for
  - 8.5. Mechanism of asexual reproduction….
  - 8.6. Phylogenetic history of asexual reproduction…
- Some recommended searches on Web of Science:
  - “parthenogenetic whiptail lizard” AND “Crews D”
  - Neaves & Baumann 2011
- Recommended searches on scholar.google.com
  - “asexual”
  - “parthenogenetic”
- Dialogue
  - Volunteer to chat on Q8.5, Q8.6
  - Post examples/sources to Blog3 Unit 8