

## ENTOMOPHAGY: EDIBLE INSECTS

LECTURE 4 – ENVIRONMENTAL BENEFITS & ETHICS

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### WHY NOT EAT HUMAN?

- QUESTION: Why do we *not* eat human meat?

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### WHY NOT EAT HUMAN?

- Obviously illegal...
- Risk of disease
  - Kuru – tremors, ataxia, laughter, paralysis, infection, death

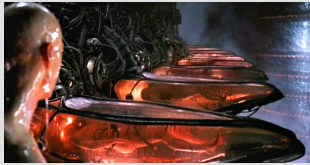



Child with advanced kuru

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### WHY NOT EAT HUMAN?

- Human meat is *the least sustainable* food and *the most empathy-generating*

The Matrix 黑客帝國 (1999)      Daybreakers 血世紀 (2009)

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### CAN INSECTS SAVE THE WORLD?

- Lots of marketing for insects as “saving the world.”
- Question: Can someone summarize the argument?






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### CAN INSECTS SAVE THE WORLD?

- In 2050, earth may have >9billion (90億) people
- Food production must increase by 70%



FAO. 2009. “How to Feed the World in 2050.”

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## CAN INSECTS SAVE THE WORLD?

- Humans are eating more food, and more of it is meat.

**Increase in global consumption of animal protein**

100% INCREASE

1970 2013 2030

**Global average calorie intake per person**

2,250 2,750 3,070

1961 2007 2050

App and Usual and Higher Energy

FAO. 2009. "How to Feed the World in 2050."

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## TERMS

- Food – What we humans eat
- Feed – What the food eats [substrate, feedstock]
- Livestock – Farmed mammals and birds

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## THE PROBLEM WITH MEAT

- Feed to Protein Ratio
- Much inedible matter
- Water usage
- Animal waste
- Land use
- Competition with human food
- Greenhouse gas emissions

**What does it take to make a ¼ lb. burger?**

<b>feed</b>	6.7 Pounds of grain and forage	
<b>water</b>	52.8 Gallons for drinking and irrigating feed crops	
<b>land</b>	74.5 Square feet for grazing and growing feed crops	
<b>energy</b>	1,036 BTUs for feed production and transport – enough to power 7 iPads	
<b>GHG</b>	13.4 Pounds of CO2 equivalent released	

Source: J.L. Clapper, Journal of Animal Science, July, 2011.  
Credit: Producers: Mike Wendig, Janice Stiller-Cornell, Designer: Karin Ehrmancher/NPR

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## THE PROBLEM WITH MEAT

- The problem: mammals and birds are warm-blooded
- Insects are cold blooded. Higher **conversion ratio**

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## THE BENEFIT OF INSECTS

- More edible body mass. More protein per resources!

**INSECTEN ALS VOEDSEL**

 Diervoeding Rendement: 13%	 Diervoeding Rendement: 33%	 Diervoeding Rendement: 60%
Lichaamsgewicht 50%	Lichaamsgewicht 50%	Lichaamsgewicht 90%
Consumeerbare vlees 50%		

Meest gegeten insecten wereldwijd: Termieten 22%, Cveing 17%, Rippen 18%, Luizen 24%, Spreekruen 19%

Omzetting van diervoeding in lichaamsmassa en consumeerbles

**Animal Feed -> Body weight -> Consumable meat**

<https://duurzaaminsten.nl/faq/cifers/>

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## THE BENEFIT OF INSECTS

- Can eat inedible feeds: organic side streams, wastes

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### THE BENEFIT OF INSECTS

- Produce less CO<sub>2</sub>, ammonia, greenhouse gasses
- Only Blattodea [cockroaches, termites] make methane

**GREENHOUSE GASSES**  
LIVESTOCK PRODUCTION CREATES MASSIVE AMOUNTS OF GREENHOUSE GAS EMISSIONS (GHG). GLOBALLY IT AMOUNTS TO MORE THAN AUTOMOBILE EMISSIONS. INSECT FARMING IS MORE EFFICIENT AND ENVIRONMENTALLY SOUND

CHICKEN	PORK	BEEF	CRICKET
300 GRAMS	1,130 GRAMS	2,850 GRAMS	1 GRAM

AVERAGE GHG FROM THE PRODUCTION OF 1KG OF PROTEIN  
RESEARCH PROVIDED BY: FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS. FURTHER INSECTS OFFER PROSPECTS FOR FOOD AND FEED SECURITY. INFOGRAPHIC BY JUSTIN KYLE NEY FOR LITTLE HERDS BLOG

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### THE BENEFIT OF INSECTS

- Require less water.

**LITERS OF WATER TO MAKE 1 KG OF PROTEIN:**

CRICKET	CHICKEN	BEEF
8	1250	8350

**GRAMS OF PROTEIN PER 100 GALLONS OF WATER**

BEEF	CORN	CHICKEN	SOY	CRICKETS
6 G	13 G	19 G	63 G	71 G

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### THE BENEFIT OF INSECTS

- Not land-based. No land-clearing. Can rear vertically.
- Most land use [for insects and livestock] is for the feed.

**A SMARTER WAY TO UTILIZE LAND**  
70% OF ARABLE LAND GOES TO MEAT PRODUCTION, EITHER DIRECTLY FOR PASTURE LAND OR FOR GROWING FEED FOR LIVESTOCK. INSECT FARMING ON AVERAGE REQUIRES MUCH LESS LAND DUE TO MANY INNOVATIONS INCLUDING VERTICAL FARMING TECHNIQUES

200 SQUARE METERS OF ARABLE LAND	50 SQUARE METERS OF ARABLE LAND	45 SQUARE METERS OF ARABLE LAND
TO PRODUCE 1KG OF BEEF	TO PRODUCE 1KG OF PORK	TO PRODUCE 1KG OF CHICKEN

RESEARCH PROVIDED BY: FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS. DOUBLE INSECTS OFFER PROSPECTS FOR FOOD AND FEED SECURITY. INFOGRAPHIC BY JUSTIN KYLE NEY FOR LITTLE HERDS BLOG

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### THE BENEFIT OF INSECTS

- Less risk of transmitting zoonotic diseases to humans, wildlife
- No need for antibiotics

**Mad Cow Disease 瘋牛病**      **SARS 嚴重急性呼吸道綜合徵**

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### THE BENEFIT OF INSECTS

- Low tech, low capital -> Lower barriers to entry
  - Easy for the poor, landless, women in developing nations

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### TO SAVE THE PLANET

- Is insect protein better than vegetable protein?
  - Soy takes more land, which means cut down forests. Some more water.
  - Plants absorb CO<sub>2</sub>, require no feed, and are vegan-friendly

**Comparing Carbon Footprints (t CO<sub>2</sub>e)**

Shrink That Footprint

Meat Lover	Average	No Beef	Vegetarian	Vegan
3.3	2.5	1.9	1.7	1.5

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**In order to feed everyone in the future, we'll have to embrace one of two diets.**



or

According to a detailed new study, by 2050, it will be very difficult to feed the world's 9.3 billion people. However, if the world were to adopt a vegan diet, there will be more than enough food. Since the study's authors don't think enough people will become vegan, they suggest enticing people to consider edible insects.

**Which diet would you choose?**

Source: neres.discovery.com

**VeganStreet.com**  
peteoc.com/vlogstreet

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**TO SAVE THE PLANET?**

- PETA and other vegan groups have complained



**Why Crickets Are Friends, Not Food**

“為什麼蟋蟀是朋友而不是食物”

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**TO SAVE THE PLANET?**

- **Entovegan** – plants and sustainable insects.  
[term invented by company selling insect-based cosmetics]



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**TO SAVE THE PLANET**

- **Poll:** What is easier? Getting people to be vegan, or to eat insects instead of animal meat?

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**TO SAVE THE PLANET**

- “Impossible Foods” and “Beyond Meat”
  - Soy and pea flour burgers respectively.
  - Soy heme and beet juice added so meat even “bleeds”



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**TO SAVE THE PLANET**

- Other sources of protein
  - Algae <- Absorbs CO2 well, vegan



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### TO SAVE THE PLANET


- Other sources of protein
  - Fungi / Mycoprotein <- Vegan, meat-like, well accepted




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### TO SAVE THE PLANET

- Other sources of protein
  - In vitro* meat <- Actually is meat. Currently expensive.



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### TO SAVE THE PLANET

- Other sources of protein
  - In vitro* seafood (Ex: ShioK Meats, Singapore)

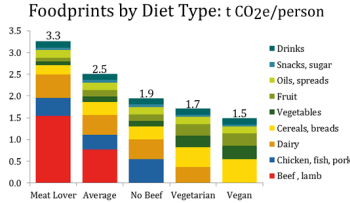


<https://www.youtube.com/watch?v=uJH82M54ZK0>

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### TO SAVE THE PLANET

- To save the planet, do we need *more insects* or *less livestock*?



**Foodprints by Diet Type: t CO<sub>2</sub>e/person**

Diet Type	Foodprint (t CO <sub>2</sub> e/person)
Meat Lover	3.3
Average	2.5
No Beef	1.9
Vegetarian	1.7
Vegan	1.5

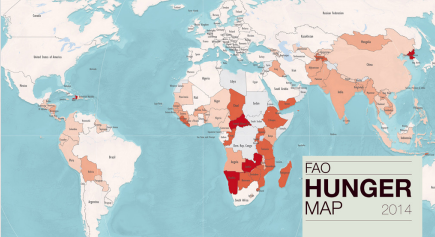
Note: All estimates based on average food production emissions for the US. Footprints include emissions from supply chain losses, consumer waste and consumption. Each of the four example diets is based on 2,600 kcal of food consumed per day, which in the US equates to around 3,900 kcal of supplied food.

Sources: ERS/USDA, various LCA and EIO-LCA data

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### TO SAVE THE PLANET


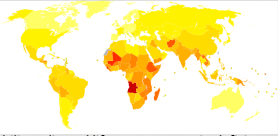
- The main benefits of insects are not to Westerners, but to impoverished areas without other protein sources



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### TO SAVE THE PLANET

- Protein deficiency is a separate problem from starvation
- The benefit of edible insects is strongest in these areas!

Disability-adjusted life years to protein deficiency

*Kwashiorkor* – symptoms of protein deficiency

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### TO SAVE THE PLANET

- Summary:
  - Insects more sustainable than mammals or birds
    - Great if they are used to replace meat
  - If insects are reared on waste, even more sustainable
  - Insects can be farmed with few resources, ideal for food insecure parts of the world
  - Eating insects less cruel than eating vertebrates... right?
    - Are insects better than plants?

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### THE ETHICS OF EATING INSECTS

- Group Discussion: Is it ethical to kill an insect? If so, when?

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### THE ETHICS OF EATING INSECTS

- Poll: When is it OK to kill an insect?
  - A mosquito flies nearby
  - A moth eats your clothing
  - A bug eats your crops
  - A fruit fly bred in the laboratory
  - A beetle for your collection
  - A cockroach in the house
  - A pet cockroach named Ralph
    - To feed your pet lizard
    - To feed yourself
  - A cricket from the farm

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### THE ETHICS OF EATING INSECTS

<https://www.youtube.com/watch?v=W083nSzx1Rc>

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### THE ETHICS OF EATING INSECTS

- Unacceptable to strict Jainists and ultra-vegans

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### THE ETHICS OF EATING INSECTS

- **Moral status** – Humans have a moral obligation to it
- If you want to uphold animal rights, you must also uphold insect rights... right?

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### THE ETHICS OF EATING INSECTS

- Moral status – Humans have a moral obligation to it
- A line must be drawn somewhere...



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### THE ETHICS OF EATING INSECTS

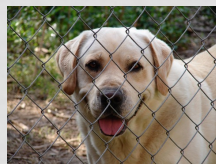
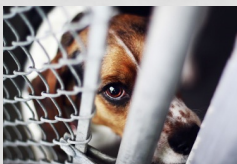
- Moral status – Humans have a moral obligation to it
- A line must be drawn somewhere...
- When is it OK to kill an animal? According to whom?



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### ANIMAL RIGHTS VS WELFARE

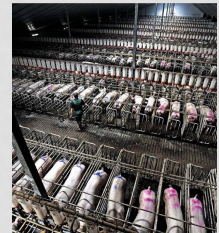
- Animal Rights 動物權益 vs Animal Welfare 動物福利



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### WHO CARES?

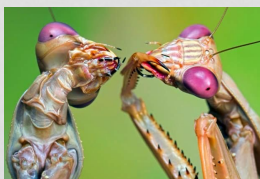
- Are insect rights/welfare a “first world problem?”
- Most rights organizations ignore insects
- People only started caring about insect welfare when we started raising them for food.
  - Associated with factory farming
  - Bad conditions suggest unclean food, risk to humans
  - UK survey found insect farmers and consumers both concerned about insect welfare



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### THE ETHICS OF EATING INSECTS

- Questions:
  - Can insects feel pain? Stress?
  - Can they suffer? Are insects conscious?
  - What's the best way to farm them ethically?



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### THE ETHICS OF EATING INSECTS

- “What Is it Like to Be a Bat?” – Thomas Nagel, 1974



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### WHAT IS CONSCIOUSNESS?

- Do cows feel pain? Do cows suffer? Are cows conscious?
  - Yes



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### WHAT IS CONSCIOUSNESS?

- Do fish feel pain? Do fish suffer? Are fish conscious?
  - How can you tell?



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### THE ETHICS OF EATING INSECTS

- Poll:** Do you think insects can...
  - Sense pain?
  - Think?
  - Feel fear?
  - Feel sadness?
  - Identify as an individual?



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### WHAT IS PAIN?

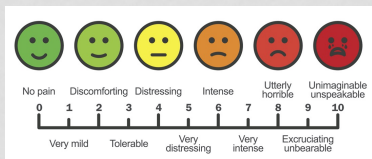
- Nociception** – “the sensory perception of potentially damaging noxious stimuli”
  - Requires nerves called “nociceptors.” What you *sense*



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### WHAT IS PAIN?

- Pain** – “an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage” - The International Association for the Study of Pain
  - Emotional state of the brain. What you *feel*.



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### WHAT IS NOCICEPTION?

- Nociception and pain alert us to damage.
  - Chronic Insensitivity to Pain: rare mutation in nociceptors. Cannot feel burns, injuries, broken bones, need to urinate



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### WHAT IS PAIN?

- You can have nociception without pain [sense, not feel]
  - Opioids reduce or block pain from reaching the brain
- You can have pain without nociception [feel, not sense]
  - Ex: Pain asymbolia, phantom pain



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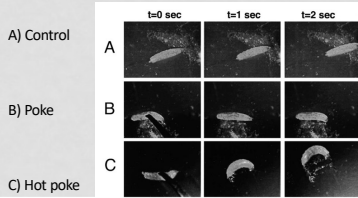
### WHAT IS PAIN?

- Group Discussion:
  - How can you tell if something *senses* pain?
  - How can you tell if something *feels* pain?

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### CAN INSECTS FEEL PAIN?

- Insects have nociceptors. They can *sense* pain.
  - Sense sharp pokes, heat, and chemicals
  - Poking or heating *Drosophila* larvae makes them roll away
  - Painless* gene similar to human nociceptor gene, prevents rolling



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### CAN INSECTS FEEL PAIN?

- No “visceral nociceptors.” No internal pain!
- Insects sense acute pain, not chronic pain or past damage
  - Will walk on broken limbs like normal

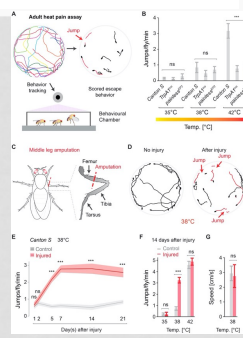


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### CAN INSECTS FEEL PAIN?

- After healing, insect legs can become hypersensitized
  - Respond to higher temperatures than usual.
  - Neuropathic vigilance is the ancestor to chronic pain.

**Insects can sense pain, but not all types of pain.**



<https://advances.sciencemag.org/content/5/7/eaaw4099>

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### WHAT IS SUFFERING?

- Pain ≠ Suffering
  - Subjective, emotional feeling of pain.
  - A concept that an alternative is better

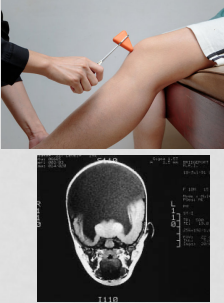


Rose, James D. "The neurobehavioral nature of fishes and the question of awareness and pain." *Reviews in Fisheries Science* 10.1 (2002): 1-38.

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### WHAT IS SUFFERING?

- Responses must *not* be reflexes
- Facial expressions, shouting, etc. are for pain, not suffering
- Decorticate humans will show all signs of pain, even though they cannot suffer!




Rose, James D. "The neurobehavioral nature of fishes and the question of awareness and pain." *Reviews in Fisheries Science* 10.1 (2002): 1-38.

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### WHAT IS SUFFERING?


- Nociception -> Behavior to escape pain
- Suffering -> Avoidance of normal behavior
  - Animal in pain won't eat or mate
  - Animal with damaged body part won't move it, will hide it



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### CAN INSECTS SUFFER?

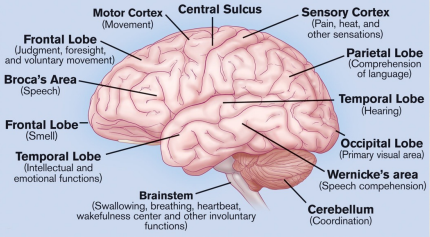
- Insects do not stop normal behavior (ex: mating) due to injury
- Do they not *feel* the pain, or not *care*?



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### CAN INSECTS SUFFER?

- Emotional brain requires more brain cells
  - No pain/suffering center in insect brain. No room




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### CAN INSECTS SUFFER?

- Insects have opioid receptors... but these have many functions
  - Honey bees with a paperclip pinching the leg or an amputated leg given sugar or sugar + morphine
    - No effect of paperclip. Amputees drank more of everything.
    - Neither treatment was "painful"

**No evidence that insects can suffer currently exists.**




<https://www.nature.com/articles/srep45825>

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### HOW IS THIS POSSIBLE?


- Suffering alerts us to chronic damage.
  - Avoid causing more damage, and wait until you heal
- Only makes sense for long-lived animals
  - For short-lived animals, suffering is pointless



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### WHAT IS CONSCIOUSNESS?

- Are insects **conscious**? Are insects self-aware?
- Or are they only acting on instinctive programming?
  - Unconscious robots can learn, think, and even sense pain
- **No universally agreed-upon definition of consciousness**




*Affetto*, a Japanese robot that can sense "painful" touch

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### WHAT IS CONSCIOUSNESS?


- Do plants feel pain? Do plants suffer? Are plants conscious?
  - No, no, and no.
  - No nervous system
  - No evolutionary benefit
  - Responding to stimuli is *not* nociception
  - Responding to damage is *not* suffering
  - Not all life needs to behave like humans!



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### WHAT IS CONSCIOUSNESS?


- Does positive music make plants grow better?
- Result of experiment by *Mythbusters*:
  - No music < Speech [positive or negative]
  - < Classical music < Intense and violent death metal
- Vibrations *do* increase plant growth
- Music improves gardener's mood.



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### WHAT IS CONSCIOUSNESS?

- Does positive music make insects grow better?
  - Probably not, but feel free to test it yourself

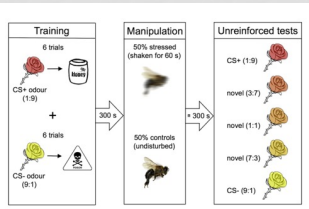


Cicada keeping me awake at night. Well guess what [redacted] It's Baby Shark on 12 hour loop

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### WHAT ABOUT STRESS?

- Insects can be **stressed**, but is this consciousness?
  - Shaking a bee makes them avoid risky decisions.
  - Hormonal, not emotional.



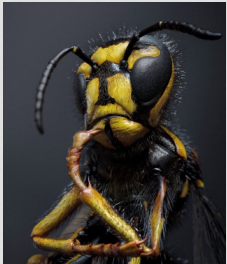
Training: 6 trials. CS+ odour (1-9) + CS- odour (8-1). Manipulation: 50% stressed (shaken for 60 s) vs 50% controls (undisturbed). Unreinforced tests: CS+ (1-9), novel (3-7), novel (1-1), novel (7-3), CS- (8-1).

doi: [10.1016/j.cub.2011.05.017](https://doi.org/10.1016/j.cub.2011.05.017)

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### DO INSECTS HAVE MORAL STATUS?

- Can insects *sense* pain?
  - Yes
- Can insects *feel* pain?
  - Maybe? No evidence.
- Can insects be physically stressed?
  - Yes
- Can insects be emotionally stressed?
  - Maybe? No evidence.
- Are insects conscious?
  - Define consciousness...



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### BEST PRACTICES


- Still required to raise [and kill] animals humanely
  - “Precautionary principle.” Assume they are conscious.
- In lab, assume they feel pain, so anaesthetize or kill quickly
- We will discuss farming in lecture 6.

GOOD AGRICULTURAL PRACTICES FOR FRESH FARMING

with National Alliance of Agricultural Consultants and Farm Advisors

Member of the National Farm Management Association




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### BEST PRACTICES

- Death should be “painless, fast, reliable, non-reversible, not psychologically stressful, and economically acceptable”
  - Non-reversible: insects can survive things that kill others
  - Freezing and freeze-drying common
  - Shredding is best

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### WELFARE IS WIN-WIN

- If people know that insects are treated well, no objections
- Insect welfare + profits maximized by good farming practices
- No proof of suffering + most people don't care




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### HOMEWORK

- Weekly Discussion assignment

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### HOMEWORK

- Copy-pasting text from another author is **NEVER** acceptable!
  - If you must copy words, use “quotation marks” and cite your source.  
使用引號並引用您的來源。
  - Copying without “quotation marks” and without citations is **plagiarism** (竊), and is **NEVER** allowed!  
切勿複製黏貼他人的文字。
  - Always better to write in your own words  
用自己的話寫總是更好
- 如何在學術論文中正確的引用文獻和使用正確的引文格式？

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### HOMEWORK

- How to cite sources
- 論文引用格式-如何在學術論文中正確的引用文獻
- <https://www.editing.tw/blog/writing/論文引用格式-如何在學術論文中正確的引用文獻.html>

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