ECOLOGY

SAMPLE LESSON PACKAGE FOR BIOLOGY

PROJECT TITLE

Investigative Analysis and Structured Argumentation (IASA)
for seeding critical thinking and inquiry skills for the 21st century
[An EDULAB Project]

RESEARCH TEAM

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SAMPLE LESSON PACKAGE FOR BIOLOGY: FIGHTING DENGUE (ECOLOGY)

INTRODUCTION

This lesson plan on Ecology is based on a learning task called "Fighting Dengue". The learning task requires students to role play as a member of a special task force set up by the environmental council. Students are tasked to select the best control measure to fight dengue outbreaks based on its effects on biodiversity conservation. A set of articles are provided to students as a source of evidence to support their decision in selecting the best control measure.

LEARNING TASK OBJECTIVES

In addition to the general objectives of CER learning task (see Section 1), "Fighting Dengue" learning task is able to fulfil some of the learning objectives stipulated in the MOE's Science Syllabus 2013, as indicated by the underlined objectives below.

Knowledge, Understanding, and Application (KUA)

1. show an understanding of an ecosystem as the interactions between a community and its physical environment
2. explain the importance of various physical factors like air, water, temperature, light, minerals and acidity/alkalinity, to the life of the organisms
3. recognise how adaptive traits (structural or behavioural) and changes in environmental conditions can affect the survival of organisms
4. show an understanding of the interrelationship among the various organisms in a community (Examples of interrelationships are predator-prey relationship, mutualism and parasitism)
5. explain the importance of conserving the environment
6. show an understanding of how respiration and photosynthesis are related to the flow of energy through food chains and food webs
7. describe how nutrients trapped in living organisms are recycled within the environment, through the actions of decomposers

Skills and Processes (SP)

1. investigate an environment using measurement instruments such as datalogger probes to collect data on physical quantities such as pH, temperature and light intensity
2. compare photosynthesis and respiration
3. compare respiration and breathing in terms of the roles they play in the interactions between living things and their environment
4. infer the role of decomposers in recycling of nutrients in the environment

Ethics and Attitude (EA)

1. show an awareness of how some cultures practise sustainable living through their interactions with the environment
2. evaluate the impact of human activities and technologies on the environment (e.g. motor vehicles and modern lifestyle)

LEARNING TASK RESOURCES

"Fighting Dengue" learning task is accompanied by the following resources to support students in constructing the required scientific argument.

	Resource	Rationale	Page
1	Task Narrative: *Fighting Dengue Infection*	• To present students with the main task • To elicit students' pre-existing ideas on some control measures • To make connection to CER	4-6
2	Mini-quiz: *How much do you know about dengue and mosquito?*	• To ensure that students have some prerequisite ideas about the control measures	7
3	My Dengue Journal	• For students to explore, consolidate and analyse information gathered • For students to make dimensional analysis of the control measures • To make connection to the task	8-10
4	Newsletter: *Dengue Digest*	• To present students with relevant information for evidence	11-17
5	Final report: *Final Task Force Meeting*	• To complete the task • To apply the CER framework	18-21

RESOURCES FOR TEACHERS

Primarily for teacher use, these resources provide additional guidance to conduct their lessons in ways that align with the IASA instructional model.

	Resource	Description	Page
1	Lesson plan	• A table containing the corresponding objective, activity, rationale, resources, and notes for the separate phases of task introduction, conceptual development and argument writing.	22-24
2	Classroom talk to integrate CER and learning task	• Examples of teacher talk and questioning to facilitate classroom discussion are provided	25-28
3	Sample CERs	• A few samples of CER are illustrated with explanations for their quality.	29-33
4	Potential preconceptions of Ecology	• A table containing not-so-accurate ideas that students may give in their CER 1. This can help teachers to anticipate potential challenges that their students may face. Possible solutions to address them are also provided.	34-35
5	Additional resources	• Sample slides to support students' argument construction, and to help link the argumentation task to classroom discussions of scientific concepts	36-46

Fighting Dengue Infection

Invitation

You have been invited to be a member of a special task force set up by the Environmental Council. The aim of this task force is to fight the recent nation-wide outbreaks of dengue. The special task force looks into the **impacts of the various control measures** that can be introduced to fight the dengue outbreaks. Specifically, your task force will look into the impact of dengue control measures on **Biodiversity Conservation**.

As part of the task force, you are responsible to produce a *mini-scientific report* on the best approach for fighting the dengue outbreaks while still conserving biodiversity in our environment. Your report will play a crucial role in influencing the Environmental Council who will propose the best approach to tackle the dengue outbreaks in the months to come.

Task force selection

I. What are your thoughts about biodiversity conservation? In your opinion, why do you think biodiversity conservation is important to consider in dengue prevention?

II. Write down how you think the three control measures will affect biodiversity conservation.

Control measure	How will the control measure affect biodiversity conservation?
1. Fogging	
2. Reducing mosquito breeding sites	
3. Using mosquito-eating fishes	

Based on your initial thoughts so far, which of the three control measures would you recommend to the environmental council as effective control of dengue? Explain your choice.

Mini-quiz: How much do you know about dengue and mosquito?

Choose the best answer. Write the letter of your choice on the line for each item.

_____ 1. Which stage of the mosquito life cycle is targeted by fogging with insecticides?

a. egg
b. larva
c. pupa
d. adult

_____ 2. Which statement is NOT a benefit of fogging?

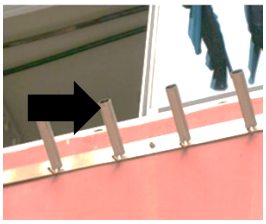
a. Fogging eliminates mosquito breeding sites.
b. Fogging kills dengue-carrying mosquitoes.
c. Fogging slows down transmission.

_____ 3. Which is NOT a mosquito breeding site that can be found at home?

a. plant pot plates

b. toilet bowl

c. bamboo pole holders



d. fish tank containing guppies

_____ 4. Which of the following statements is NOT a reason for removing watery spots?

a. To prevent mosquito larvae from growing
b. To eliminate the areas where mosquitoes can lay eggs
c. To eliminate areas where adult mosquitoes can hide in
d. To remove mosquito pupae that may grow in these spots

_____ 5. What is the ecological relationship between Siamese fighting fish and mosquitoes?

a. host – parasite
b. predator – prey
c. mutualistic relationship

_____ 6. Natural control, sometimes called biological control, relies on natural enemies to control pest organisms such as mosquitoes. Which of the following is NOT an example of a specific natural control action?

a. adopting guppies as pets
b. breeding Siamese fighting fish
c. protecting the mosquitofish population
d. fishing in reservoirs

My Dengue Journal

As you go through the lessons on Ecology, here are some questions to think about:

1. How would changes in the environment affect the growth and population of mosquitoes? (Hint: think about the physical and biotic factors)
2. How will each of the three control measures (e.g., fogging, removal of breeding sites, and introducing predators) affect the life cycle of mosquito?
3. How will 'removing' the various life stages of mosquito (e.g., egg, larva, pupa, adult) affect the food chains?

Write down your thoughts and any useful notes in the space below.

In light of what you have learnt, use the space below to list down the pros and cons that you could think of for each of the three dengue control measures.

Control Measure	Pros	Cons
Fogging		
Reducing breeding sites		
Using mosquito-eating fishes		

DENGUE DIGEST

Ecology Newsletter July 2016

Control measures against dengue infection

This special edition of our Ecology Newsletter is devoted to a discussion on several control measures for dengue infections. You may well know that the number of dengue cases this year is predicted to increase. It is thus important to find out the best way to stop the spread of the dengue virus through mosquitoes. This newsletter is a compilation of new articles, excerpts from scientific articles, opinion pieces and other bits of helpful information about dengue control measures. Fogging and reducing breeding sites are control measures that have already been implemented by the Singapore government for quite some time. Another measure—use of mosquito-eating fishes — is still being studied for future implementation. You will find essential information on these three control measures inside.

A campaign poster for preventing dengue fever

In This Issue

- What is fogging?
- Are we at risk when exposed to pyrethroid substances?
- What has been achieved from the effort of reducing breeding sites over the years?
- What is biological control?

… and many other stories

What is Fogging?

Fogging involves spraying tiny droplets of concentrated insecticide in areas with many reported cases of dengue infection. What fogging seeks to do is to kill, or 'knock-down' any adult mosquitoes that could be carrying the dengue virus. Mosquitoes get the virus after biting and taking blood from a person who is sick with dengue. These dengue-carrying mosquitoes, on their next round of a blood meal, could possibly infect healthy individuals. To prevent dengue from spreading, mosquito fogging is done in areas that are already on red alert for dengue cases. By killing adult mosquitoes, fogging could prevent further transmission of the dengue virus.

Fogging is done in open spaces surrounding residential areas and construction sites. It is carried out during periods of the day when mosquitoes are most active and in search of blood meals, typically around dawn and dusk. During outdoor fogging, residents are advised to open their doors and windows open so that sprayed insecticide can penetrate houses and kill any mosquitoes living inside. This step is important because the mosquitoes prefers staying indoors. At the beginning stages of an outbreak, the World Health Organization recommends fogging inside houses of dengue patients to prevent further spread of infections.

[Source: US Environmental Protection Agency; World Health Organization]

Are we at risk when exposed to pyrethroid substances?

Pyrethroids are insecticides included in over 3,500 registered commercial products, many of which are used widely in and around households, including on pets and in treated clothing, in mosquito control, and in agriculture.

Pyrethroids are less harmful than other pesticides that have been used in the past and found harmful to birds and mammals.

Concerns about residential use of pyrethroids have been raised because they may be washed off by rainwater to nearby bodies of water, potentially exposing aquatic organisms to harmful levels.

In October 2011, a Pyrethroid Risk Assessment was conducted by the US Environmental Protection Agency. The results indicate that exposures from the many current uses of pyrethroid insecticides do not pose risk concerns for children or adults.

Agency scientists have concluded that there does not appear to be a clear relationship between pyrethroid exposure and asthma/allergies.

This risk assessment is highly conservative, overestimating actual risk. That is, the assessment assumes that people are exposed to the highest levels of residues in food, water, and in their homes, all on the same day. Even with these conservative and protective assumptions, the assessment shows that cumulative risks for both children and adults are not of concern for the currently registered uses of pyrethroid pesticides. Even with very favorable findings, the agency will continue to evaluate new data on this issue as it becomes available.

[Source: US Environmental Protection Agency]

Active ingredients used in fogging

The insecticide used in fogging belongs to a group of synthetic chemicals called pyrethroids. Pyrethroids instantly paralyse and kill adult mosquitoes. If mosquitoes carrying the dengue virus are knocked down, then the spread of dengue infections could be stopped. One of several pyrethroids available for use in fogging is Cypermethrin. Cypermethrin is the same active ingredient of household products used against ants and cockroaches, like ant chalk and Raid.

[Source: World Health Organization]

AFP/Roslan Rahman; Channel News Asia

A worker fogs a housing estate in Singapore.

What is a dengue red alert?

According to the National Environment Agency, a red alert for a neighbourhood means that there are at least 10 confirmed dengue cases from the area.

[Source: National Environment Agency, Singapore]

Do mosquitoes become resistant to pyrethroid?

In some places, massive spraying has eliminated malaria. But an important concern is now coming to light because cases of mosquito-diseases are rising again mainly because of mosquitoes developing resistance against insecticides. Moreover, scientists have found that, in general, mosquitoes that are resistant to pyrethroids also become resistant to other insecticides. Because of these recent observations, there is a need to develop new control strategies against mosquito-borne diseases that could work alongside insecticide spraying. In order to come up with new strategies, it would be helpful if future research can find out exactly how mosquitoes become resistant to pyrethroids.

[Source: Pesticide Science (scientific journal), May 2006]

(Wikimedia Commons, The Verge)

A 1907 ad for the pyrethrum spray that was originally developed by Johann Zacherl, an Austrian inventor.

Concerns raised by the public on the use of fogging

THE widespread practice of thermal fogging using the insecticide cypermethrin for mosquito control in Singapore is a cause for concern.

In some areas, the residents cannot avoid inhaling the chemical several times a week because of frequent fogging in the neighbourhood. The chemical may also contaminate drain water, a source of Newater.

Cypermethrin is widely used in agriculture in many countries but seldom in densely populated areas.

The National Environment Agency believes cypermethrin is safe. But we really have no knowledge of the long-term effects of repeated exposure to the chemical on people, especially infants and children.

There are no perfectly harmless chemicals and drugs.

Take for example DDT. It was first hailed as an ideal insecticide with no harmful effects on higher forms of animals. But in 1962, scientists found that the chemical could cause cancer and harm animals high up in food chains. And in 1972, DDT was banned in America. Another example is aspirin, which was considered perfectly safe for decades but is now known to have side-effects.

A chemical or drug is used justifiably if its benefits outweigh its harmful effects.

According to a field study carried out in Malaysia and tests published in natural science journal Florida Entomologist, cypermethrin's effectiveness as a larvicide (larvae killer) is doubtful.

When there is an outbreak of a mosquito-related disease, fogging should be an immediate response to kill adult mosquitoes over several hectares at one go, while doubling the efforts to clear the area of stagnant water.

However, it is ludicrous for individual home owners to have thermal fogging carried out routinely in their compounds.

Its efficacy is short-lived and the neighbours' houses can suddenly be shrouded in a chemical fog that is probably harmful to infants and children.

The United States Environmental Protection Agency classifies cypermethrin as a possible human cancer-inducing agent. A recent study has linked pyrethroids, to which cypermethrin belongs, to leukaemia and lymphoma.

Cypermethrin is a neurotoxin that can affect brain tissue and can damage many other organs.

Let us avoid the futile individual thermal fogging, and concentrate our efforts on the key to mosquito control - prevention of stagnant water formation.

Dr Ong Siew Chey

[Source: The Straits Times forum, 20 March 2012]

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NEA's anti-dengue campaign graphic for reducing mozzie breeding sites. (National Environment Agency)

What has been achieved from the effort of reducing breeding sites over the years?

Public health response to dengue fever in Singapore dates back to 1966. By that time, the disease has become one of the leading causes of death among children. A system for controlling the mosquito population became necessary. The system that the government's health agency developed involves monitoring changes in the size of the mosquito population and reducing sources of mosquito larvae (that is, reducing the habitats of larvae). The strategy of this public health program is to reduce the mosquito breeding sites so that transmission of the dengue virus can be controlled, eventually leading to fewer cases of dengue fever.

When the program was first tested for three months, the strategy reduced the population of *Aedes aegypti* (one two mosquito species that carry the dengue virus) from 16% to 2%. The percentage is based on the count of premises having containers with *Aedes aegypti* larvae and pupae. At the conclusion of this test, the agency recommended that, in order to keep the mosquito population density low, it is important to involve the public in carrying out the strategy. This is because the mosquitoes quickly breed again in the area immediately after the agency operations shift to another site. The program must emphasise two elements to sustainable reduce mosquito breeding sites: public education and law enforcement. Government passed a law – The Destruction of Disease Bearing Insects Act of 1968 – to discourage people from breeding mosquitoes, whether intentionally or unintentionally.

Since 1973, when the mosquito control program was completed, the percentage of premises harboring mosquito larvae and pupae has remained at about 2%. It seemed impossible to reach 0% because natural breeding habitats emerge as quickly as they are removed. Nevertheless, the population of *Aedes aegypti* remained low for 15 years. But in the 1990s, the incidence of dengue steadily rose despite low mosquito population density around premises.

[Source: Emerging Infectious Diseases (scientific journal), Jun 2006]

Where do mosquitoes breed?

One way to control the population of mosquitoes that could carry the dengue virus is to reduce sites where they could breed in and around our homes. From 2012 to 2014, the top five breeding habitats in homes have remained the same (see graphic). All these habitats are watery spots that support the life cycle of mosquitoes. They are most ideal for laying and hatching eggs and for growing larvae and pupae. Most of these habitats are artificial, like bathroom pails, flower pot plates, flower vases and toilet bowls. Others are natural, like tree holes and axils of plants, which may collect rainwater that takes a long time to dry. In fact, a mosquito only needs a water drop as small as a 20 cent coin to breed and multiply!

[Source: National Environment Agency, Singapore; The Straits Times]

A fine of $200 for not keeping my home mosquito-free?

In February 2016, the Environment and Water Resources Ministry announced that it will fine homeowners $200 if their homes were found to have mosquito breeding sites. We you shocked by that news? Perhaps not. Human behaviour is difficult to change. Fines could force residents to be more mindful of their surroundings and active in dengue prevention efforts. This new enforcement action is part of the Do the Mozzie Wipeout annual national campaign.

[Source: The Straits Times, 28 Feb 2016]

Do you know?

You may not be aware of this but the anti-dengue program requires a lot of manpower resources. The National Environmental Agency (NEA) employs a large pool of about 850 officers to carry out dengue inspections on a daily basis all over Singapore. They are assigned to smaller teams that are dedicated to survey specific areas and enforce preventive actions. The NEA coordinates with land agencies, town councils, as well as their pest control operators, to carry out search and destroy operations in public areas including construction sites, schools, and residential estates.

The government alone cannot keep Singapore dengue-free, the public need to play their part. Making sure that mosquito breeding sites in our surroundings are kept to a low depends not only on the commitment of the dengue inspectors. It is a community effort!

[Source: National Environment Agency, Singapore]

NEA officers and contractors preparing to carry out inspection and fogging operations in Watten Estate.

Gold fish are kept in a tank to control the mosquito population.

What is biological control?

Biological control is based on the introduction of organisms that prey upon, parasitise, compete with, or otherwise reduce populations of the target species. Against Aedes mosquitoes, a selection of larvae-eating fish species are effective against the immature larval stages of mosquitoes.

The biological control organisms are bred and distributed into water-storage containers or wells. Small-scale projects have shown that the success of biological control is mainly reliant on the organisation of the project:

- Breeding of fish;
- Community mobilisation and participation (willingness to accept the introduction of organisms into water containers);
- Distribution system for fish (regular restocking and monitoring).

Natural Enemies of Mosquitoes

A variety of fish species have been used to eliminate mosquitoes from larger containers used to store safe, drinkable water in many countries, and in open freshwater wells, concrete irrigation ditches and industrial tanks. Commonly, guppies adapt well to these types of confined water bodies and have been most commonly used. Only native larvae-eating fish should be used because non-native species may escape into natural habitats and threaten the indigenous fauna. WHO has published further information on the use of fish for mosquito control.

[Source: World Health Organization, 23 April 2014]

The World Health Organization recommends only two types of native organisms to use for natural control of mosquitoes. The first type of organism is the group of fishes that eat larvae and pupae, an example of which is the Siamese fighting fish. The second type of is the group of copepods, which are very tiny crustaceans that are the cousins of shrimp and crabs. [Source: World Health Organization]

Characteristic	Siamese fighting fish
Adult size (mm)	650
Natural habitat	tropical freshwater
Artificial habitat	freshwater aquariums, water ponds
Food source	larvae (late stages) and pupae of mosquitoes and other insects, freshwater microorganisms, tiny crustaceans (shrimp), algae
Predators	humans, large fish, newts, salamander, turtles, frogs, snakes, birds, and wild cats
Method of mosquito control	Breed in the right conditions; Adopt as pets at home; Contain in cement fish tanks (artificial ponds)
Location of field tests	Brazil, Thailand, Mexico

[Source: University of Wisconsin-La Crosse website; Wikipedia]

Western mosquitofish

The western mosquitofish is a small fish whose native range mostly exists in the south-central United States.

Western mosquitofish feed primarily on zooplankton and invertebrate prey (including mosquito larvae) at the top of the water column. The fish is well known for its high feeding capacity, which can reach 42–167% of its body weight per day.

Because of their reputation as mosquito-control agents, western mosquitofish have been introduced in temperate and tropical areas throughout around the world. In the U.S. during the early 1900s, mosquitofish were introduced to Hawaii from Texas to test their effectiveness in preying on mosquito larvae and their ability to function as an effective mosquito predator.

In the following decades, mosquitofish were widely introduced by public health organisations, largely because they were thought to be an effective and inexpensive means of combating malaria.

In more recent years, many state and local health departments apparently view the use of mosquitofish to control mosquito larvae as a more attractive alternative to using pesticides.

Although widely introduced as mosquito control agents, more recent scientific reviews have not supported views that mosquitofish are effective in reducing mosquito populations or mosquito-borne diseases.

In some habitats, introduced mosquitofish reportedly displaced native fish species regarded as better or more efficient at controlling mosquitos. They also were destructive to predatory invertebrate populations that fed upon mosquito larvae.

Introduced mosquitofish have been particularly destructive in the American West where they have contributed to the elimination or decline of populations of federally endangered and threatened species.

For instance, mosquitofish have preyed on populations of tadpoles of certain frogs and newts, thus reducing the adult populations of these species.

[Source: Bugoff.com, 16 Mar 2015]

A western mosquitofish

Answers to the Dengue Quiz

1.1 Which stage of the mosquito life cycle is targeted by fogging with insecticides? *d. adult*

1.2 Which statement is NOT a benefit of fogging? *a. fogging eliminates mosquito breeding sites.*

2.1 Which is NOT a mosquito breeding site that is typically found at home? *d. fish tank containing guppies*

2.2 Which of the following statements is NOT a reason for removing watery spots? *c. to eliminate areas where adult mosquitoes can hide in*

3.1 What is the ecological relationship between Siamese fighting fish and mosquitoes? *b. predator – prey*

3.2 Natural control, sometimes called biological control, relies of natural enemies to control pest organisms such as mosquitoes. Which of the following is NOT an example of a specific natural control action? *d. fishing in reservoirs*

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Final Task Force Meeting

Writing the Final Scientific Report

To help the task forces in their report, the environmental council has provided a newsletter compiling all the relevant materials that are sourced by the research unit in the council. With the information provided in the newsletter, you should now be ready to submit your final report to the council.

In your final scientific report, explain your choice for the best control measure for preventing dengue infection. Elaborate on how you weighed the pros and cons for each control measure considered, according to the specified impact that your task force is responsible for looking into.

Write your final report in such a way that it satisfies the criteria for the three essential components of a good scientific explanation:

- Claim: (a) Accurate and (b) Complete
- Evidence: (a) Specific; (b) Appropriate and (c) Sufficient
- Reasoning: (a) Accurate; (b) Sufficient; (c) Display task understanding and (d) Coherent

Name of task force: _____

Task force members	Register No.

The Final Scientific Report

LESSON PLAN

"Fighting Dengue" learning task can be integrated in the classroom as shown in the following lesson plan:

	Objective	Activity	Rationale	Resources	Notes
Task introduction phase	Introduce students to the learning task	• Reading • Classroom discussion	• To familiarise students with the learning task	• *Fighting Dengue Infection* narrative worksheet (pp. 4-6)	• Important to check students' understanding of task as they may not fully comprehend what the task is about
	Introduce the control measures	• Watching videos on various control measures • Short-quiz	• To familiarise students with the three control measures • To check that students understand how the three control measures work	• YouTube videos on various control measures • Mini-quiz questionnaire: *How much do you know about dengue and mosquito?* (p. 7)	• Providing a commentary prior to or during video showing could help students attend to the relevant details
	Activate and assess students' intuitive knowledge about fighting dengue	• Writing 1st CER	• To solicit and assess students' preconceived views on biodiversity conservation and the control measures • To know how students argue for their claim • To get students to apply the CER framework	• IASA Web App: *1st CER* • *Fighting Dengue Infection* narrative worksheet (pp. 4-6)	

	Objective	Activity	Rationale	Resources	Notes
Conceptual development phase	Content knowledge development: - physical and biotic factors - interaction between organisms - food chain and web - carbon cycles - conservation and sustainability	• Classroom teaching • Classroom discussion	• To equip students with the necessary content knowledge • To relate the content knowledge to the learning task	• Supplementary slides on dengue mosquitoes: *see Additional Resources* • *My Dengue Journal* (pp. 8-10) • Newsletter: *Dengue Digest* (pp. (11-17)	
	Summarise the topic	• Classroom teaching • Classroom discussion	• To provide students with opportunities to compile, record and consolidate relevant knowledge and information related to the task	• *My Dengue Journal* (pp. 8-10)	
Argument writing phase	Assess students' understanding of ecology	• Writing 2nd CER	• To assess if students have understood the concepts taught • To get students to apply the CER framework	• IASA Web App: *2nd CER*	• Students can be reminded to use knowledge gained in class and from the newsletter and journal entries.
	Evaluate group mates' CER	• Peer critique	• To get students to critically evaluate and learn from other arguments	• IASA Web App: *Feedback*	• Some students may not know what constitutes constructive feedback so it would be beneficial to model for them

	Objective	Activity	Rationale	Resources	Notes
	Assess students' refined argumentation	• Writing final group CER	• To assess if students have understood the concepts taught • To get students to apply the CER framework	• Final report worksheet: *Final Task Force Meeting* (pp. 18-21) or • IASA Web App: *Final CER*	

INTEGRATING CER AND LEARNING TASK

"Fighting Dengue" learning task should not be seen as an additional task for students to apply their content knowledge at the end of the topic. Rather, it should be seen as the central task and be addressed seamlessly as the topic progresses. Therefore, it is important to refer to the learning task from time to time.

EXPLICIT TALK ON CER

In order to help students internalise the CER framework, it is important to explicitly talk about it. The following classroom conversation occurs right after a teacher introduces the learning task to her students. It illustrates how she explicitly guides her students to use the CER framework to argue for their choice of control measure to reduce the spread of dengue fever. She systematically and explicitly asks her students to give their initial claim, evidence, and reasoning.

So, out of these 3 control measures, you can only choose 1 and then you will say that this is your claim. Let's try. Jane, which one will you choose?

The introducing of predators.

How do I form a sentence for your claim?

I would choose to introduce the predators to decrease the spread of dengue fever while conserving biodiversity.

Good. Now, what is your evidence? Okay, first, what is evidence? Anyone?

Something that I know to support my claim.

Okay. Evidence is there to back up your claim. So, what kind of evidence do you have? What information?

The predators are introduced in water and they have no direct contact with animals on land.

Okay. Good. This is based on information that you know currently. Now, what is your reasoning? I need you to explain further how your information can back up your claim.

Uhm, because the predators live in water, they have no direct contact with animals on land. They are not able to affect the biodiversity on land. Therefore, biodiversity on land can still be conserved.

Okay. Good. So, that is roughly how you explain. You give your claim, back it up with your evidence or information, and then make your reasoning.

EXPLICIT REFERENCE TO THE LEARNING TASK

One of the ways to integrate the learning task is to use mosquitoes as the main example for most concepts. The following classroom talk suggest how the learning task can be used as an example to illustrate the concept of food chain during the conceptual developmental phase.

Just now we learnt that mosquitoes feed on plant sap. Because of this, we call mosquitos a primary consumer. What about the plants? What do you think we call them?

Producer?

Good. We call plants a producer because they can produce their own food. Now, who eats the mosquitoes? Remember the video we watched earlier?

The mosquitofish

Yes. The mosquitofish. And what do you think we call them?

Consumer?

Almost there. We call them secondary consumer. Because they consume primary consumer. Now, look, the plant sap is eaten by the mosquitoes and the mosquitoes are eaten by the mosquitofish. This whole thing, we call it a food chain. So, a food chain is a sequence of who gets eaten by whom. Or a sequence of energy transfer. It always starts with a producer, because it can make its own food, and then it is followed by a series of consumers.

QUESTIONS TO LINK CER AND LEARNING TASK

The table below shows some examples of when reference to CER and learning task can be made and some possible questions to ask students.

Qn no.	Strategic Point	Possible Question	Links to:	
			Task	CER
1	After unpacking the learning task	From the three control measures, which one do you claim to be the most effective to fight dengue while still conserving biodiversity? Why? What is your evidence?	✓	✓
2	After reading the newsletter	What evidence have you gathered to support your claim?	✓	✓
3	During content development, e.g., food web	Look at your newsletter, can you construct a food web based on what is written there?	✓	
4	During consolidation of learning	We have learnt many concepts so far. Now, think, which concepts do you think are most relevant to help you decide the best control measure?	✓	

Sample #1 – Good Argument: Structured comparison of three control measures but needs checks for accuracy

Explicitly states the claim.

Introducing non-native mosquitofish in ponds in Singapore is most likely to have minimal impact on biodiversity/cause least damage to our ecosystem as compared to the other two control measures.

Structures argument as a comparison of the three control measures

Mobilises a relevant evidence to support claim.

This is because mosquitofish can eat mosquitoes' larvae, maintaining the mosquitoes' population and as a result decrease the threat of Zika virus.

Mobilises appropriate and accurate scientific knowledge for reasoning (grey text)

With the abundance of birds of prey in Singapore, the population of mosquitofish can be controlled. This method of introducing non-natives into ponds are less destructive than others such as the fogging method, uses pyrethroids as it is toxic to other beneficial insects such as fishes, snails, tadpoles, bees and dragonflies. In addition, these harmful chemicals can be washed off by rainwater and expose aquatic organisms such as mayflies to harmful levels. Fogging affects more than one organism, causing more damage to our ecosystem.

Appropriately uses several scientific terms (underlined text)

Mentions relevant evidence on the disadvantages of fogging.

Removing artificial breeding sites of mosquitoes will cause the population of dengue to dwindle. However, with the absence of mosquitoes, the population of tadpoles and fishes will be affected as their food source has been reduced. The rate of pollination will also decrease as a result. In addition, the population of other aquatic organisms such as dragonflies and mayflies will also decrease as their breeding grounds have been removed.

The statement appears problematic since it is not known if the indigenous birds would feed on a non-native fish such as the mosquitofish.

Cites relevant evidence on the disadvantages of removing artificial breeding.

Invokes concept of food web to describe the impact of removing artificial breeding sites as part of reasoning

Sample #2 – Good Argument: Well-structured argument in clear and coherent writing

Clearly articulates claim that the removal of artificial breeding sites is the best among the three available control measures.

Cites and assesses relevant and accurate evidence on the impact of fogging on humans and other organisms

Cites and assesses relevant and accurate evidence on the environmental impact of introducing mosquitofish

Cites and assesses relevant and accurate evidence on the removal of artificial breeding sites

Frames reasoning as a comparison of the three control measures with respect to extent of impacts on biodiversity.

All the three measures are helpful to control the amount of mosquitoes. However, I feel that removing of artificial breeding sites of mosquitoes could minimize the impact on biodiversity. Comparing to fogging and introduction of mosquito-fish, removing of artificial breeding sites has the least amount of negative impact.

For fogging, it can affect the aquatic and terrestrial environment. Also, chemical substances in the fog may be toxic to people and will harm their body if they get prolonged contact with the fog or inhaling them. Other living things in the environment might also be harmed due to the toxic substances in the fog, be it prolonged contact or inhalation. This will cause negative impacts onto human health and the health of organisms.

Introducing non-native mosquitofish in ponds in Singapore will also cause many negative impacts on the biodiversity. When there are too much mosquitofish present, it will contribute to overcrowding in the fishing pond. Overtime, this will result in the lack of food for other aquatic animals. In the end, some fishes might die to lack of food. Slowly, this will cause in an unbalance of food chain. Also, as adult mosquitoes can help to pollinate plants, so if the population of mosquitoes decrease due to mosquitofish, the rate of pollination will decrease causing less plant reproduction. This will cause damage to the ecosystem.

Removing artificial breeding sites will also cause negative impact but not as much. Removing artificial breeding sites will cause the population of some animals and insects at the area to decrease. This is because those animals and insects such as tadpoles, frogs and fishes rely on mosquitoes as their food.

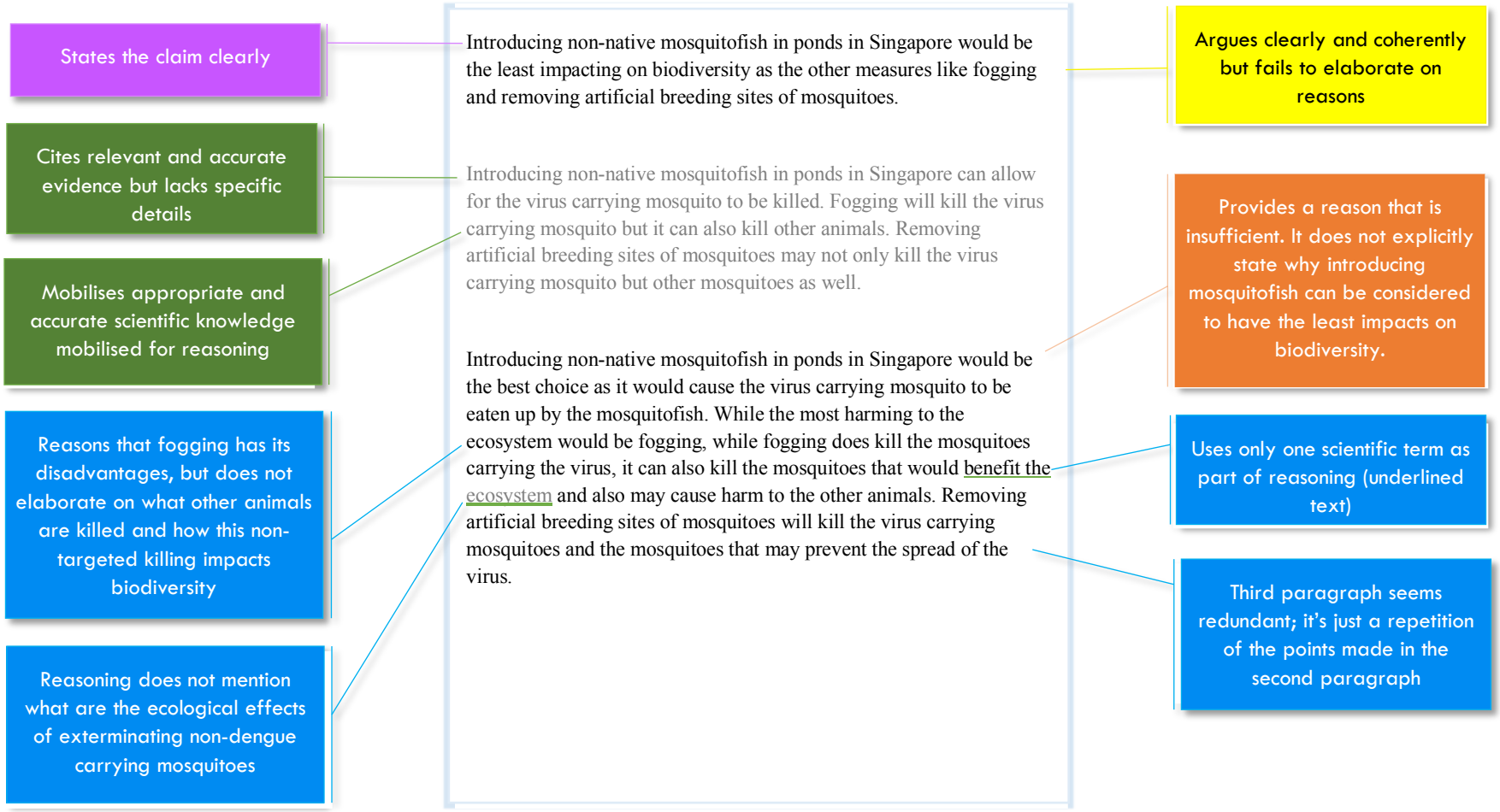
Comparing these three measures, removing artificial breeding sites does not cause as much impacts than the other two. In summary, for fogging, it will cause impacts on the health of animals, insects and human. For mosquito-fish, it will cause unbalance in the food chain which might cause extinction of certain animals. But for removing of breeding sites, it will only decrease in the population of certain animals. The population can increase if they reproduce more.

Writes the whole argument clearly and coherently

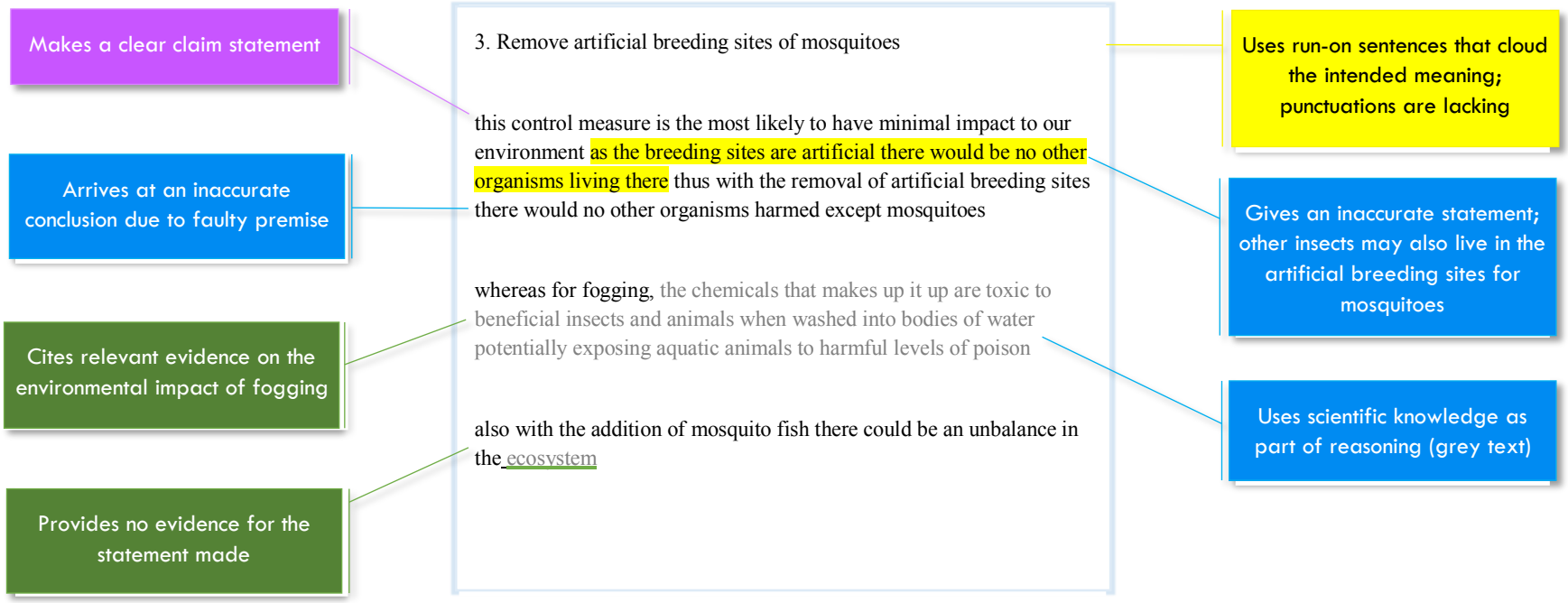
Mobilises appropriate and accurate scientific knowledge for reasoning

Appropriately uses several scientific terms (underlined text)

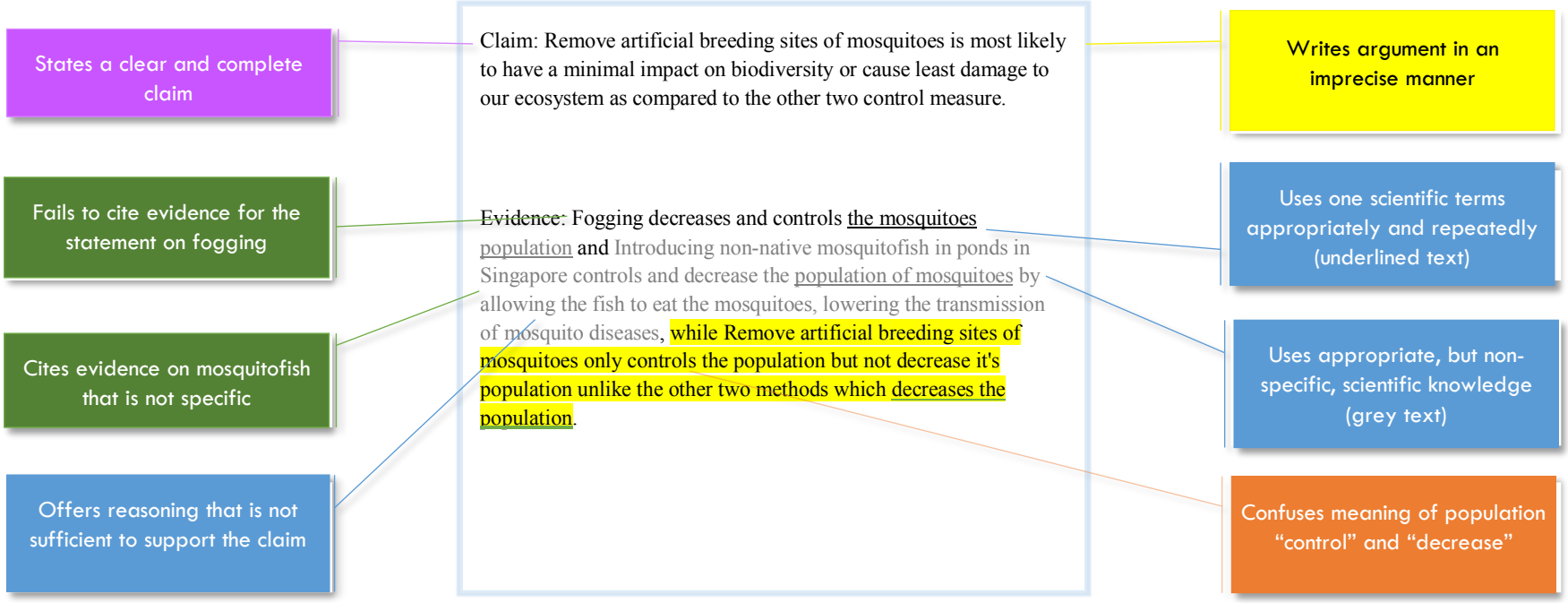
Sample #3 – Argument Needs Improvement: Clearly written but reasoning needs more specific details and justifications



Sample #4 – Argument Needs Improvement: Faulty premise in reasoning; run-on sentences makes ideas difficult to understand



Sample #5 – Argument Needs Improvement: Lacking specific citation of evidence; writing needs to be clearer and more precise



POTENTIAL PRECONCEPTIONS OF ECOLOGY

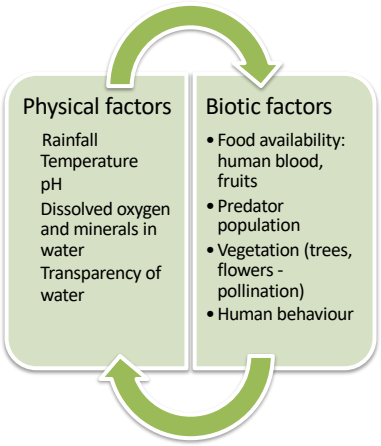
Misconception / Students' Idea	Example	Way to Address
• Students have issues with representation convention in the topic of ecology	• Students interpret the arrows in food chains and webs to represent the process of consuming rather than energy transfer. Therefore, some students draw the arrows in their food chains/webs in the opposite direction (e.g., instead of "grass → rabbit →human", students may draw "human → rabbit →grass") • A number of students do not start their food chain with a producer but with a consumer. For example: *"Mussels → Starfish → Sharks → Human"* *"Mosquito larvae → Tadpole → Mosquitofish → Birds"*	• The meaning and reason of each representation can be made explicit to students.
• Students have issues with type of relationships among organisms	• Prey-and-predator relationship is also seen as a nature way of reducing population rather than maintaining population balance. • Absorbing nutrients from hosts is not seen as a harmful activity. Therefore, students classify such relationship as commensalism.	• Implications of the different types of relationships can be elaborated • What constitute harmful activities can be elaborated further
• Students have issues differentiating physical and biotic factors	• Availability of food seen as a physical factor • Rainfall seen as a biotic factor	• Clear definition and more examples of the factors can be given, especially for biotic factors.

Misconception / Students' Idea	Example	Way to Address
• Students may use irrelevant evidence	As I'm concerned about side effects on human health, I would choose introducing predators such as mosquito-eating fishes. The fishes live in water, therefore we are not in direct contact with the fishes so human health will not be affected. The mosquitoes are in their larva stage, so they are harmless as they are not able to fly around and transmit the diseases to humans. There are no chemicals involved in this process unlike fogging, which pollutes the air thus human health is not affected. Using the mosquito-eating fishes is most effective control measure that protects the side effects of dengue on human health. The mosquito-eating fishes. Firstly, the fishes have a high feeding capacity, thus they would be able to feed on a large amount of mosquitoes, greatly decreasing the mosquito population. There was also an experiment on introducing mosquito fish into the ecosystem to test their effectiveness, and also realized it was inexpensive, which shows that it wouldn't affect the economy of the country as much as introducing wolbachia-carrying mosquitoes.	• Students could be asked to list relevant information before writing their reports. • Students could be reminded to ask themselves if the evidence they quote are relevant.
• Students may not use a complete set of evidence	• Students only consider the advantages of fogging but disregard its disadvantages. • *"This is because Fogging only kills the adult mosquitoes and not the larvae of the mosquitoes.This will reduce the amount of cases of dengue fever and other diseases like Zika ,which are carried by adult mosquitoes.Also,but killing only the adult mosquitoes and not the larvae will prevent an inbalance in the eco system."*	• Students could be reminded to look at matters holistically and consider all relevant evidence.

Prepared by IASA Team (Edulab/NIE)

Resources for teaching ecology - in relation to Dengue Learning Task

Mosquitoes and their Environment



Physical factors affecting mosquito growth

Physical factor	Effect on mosquito
Rainfall	Water is needed for mosquito eggs to hatch and for their pupae and larvae to grow
Dissolved oxygen in water	Mosquito larvae can tolerate very low level of dissolved oxygen since larvae of almost all species take in oxygen from the air through through a breathing tube called a siphon. However, larvae of some species have been reported to use dissolved oxygen in addition to oxygen in the air.
pH	Ades *aegypti* mosquito larvae can withstand pH level of 4-11
Temperature	Can affect the number of days in which the mosquitoes stay in the larval and pupal stage

Physical Properties of Mosquito Larvae Breeding Sties

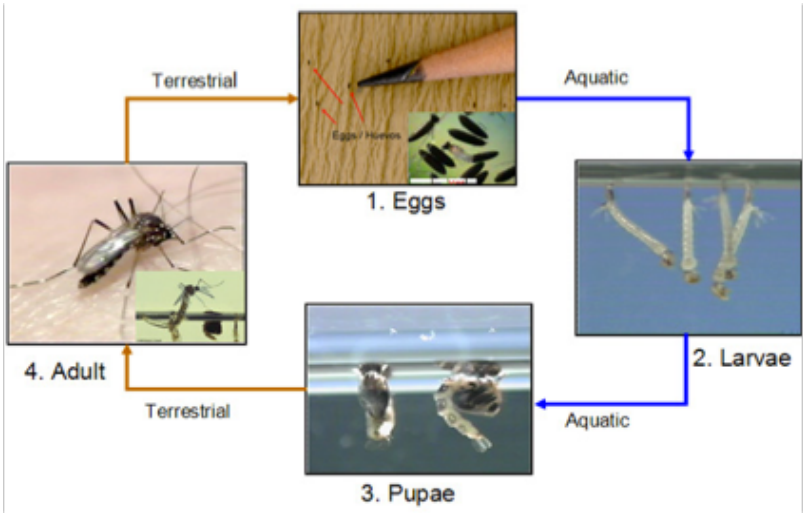
Properties	Ponds	Swamps	Rivers	Drains	Domestic containers
Temperature (°C)	26	26	26	26	26
Dissolved solids (mg/l)	6	93	90	108	124
Water transparency (m)	0.14	0.06	0.13	0.09	0.02
Dissolved oxygen (mg/l)	26	30	28	31	38
pH	8.3	8.4	8.9	6.2	8.2

Source: http://www.dengue.gov.sg/subject.asp?id=100

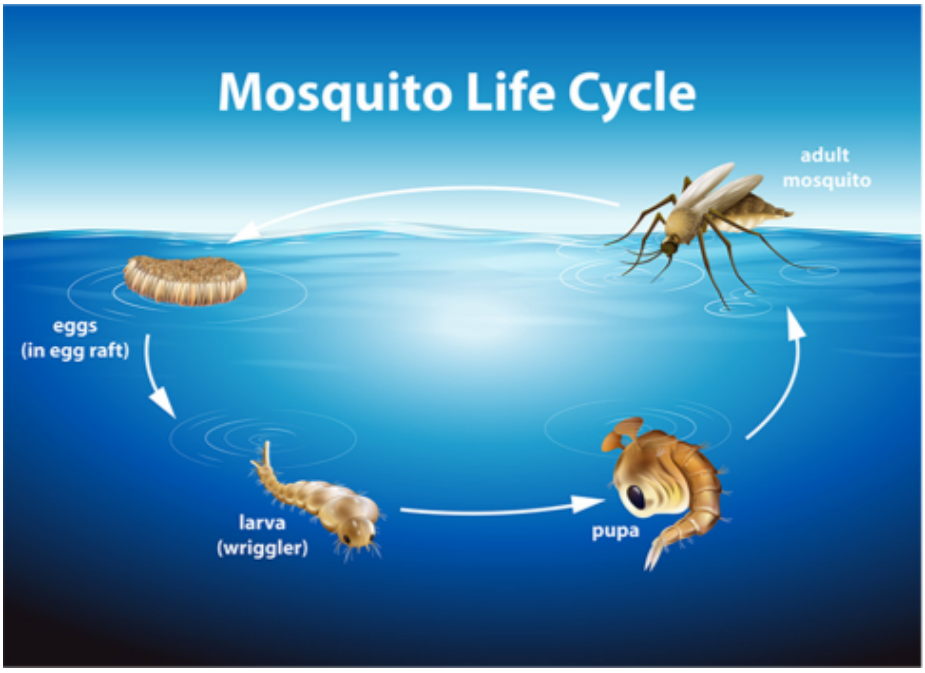
List of Mosquito Breeding Sites

Source: http://www.dengue.gov.sg/subject.asp?id=100

Mosquito Life Cycle

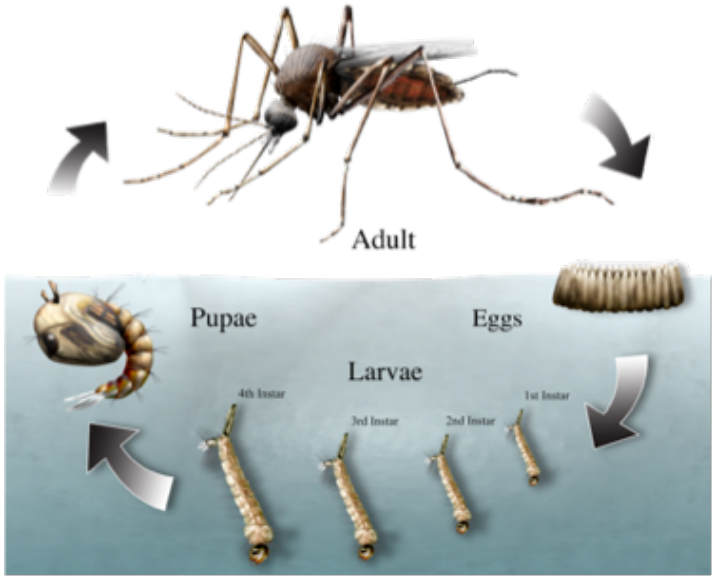


Source: http://www.cdc.gov/dengue/entomologyEcology/m_lifecycle.html



Source: http://whyfiles.org/2014/mosquitoes/

Life Stages of a Mosquito

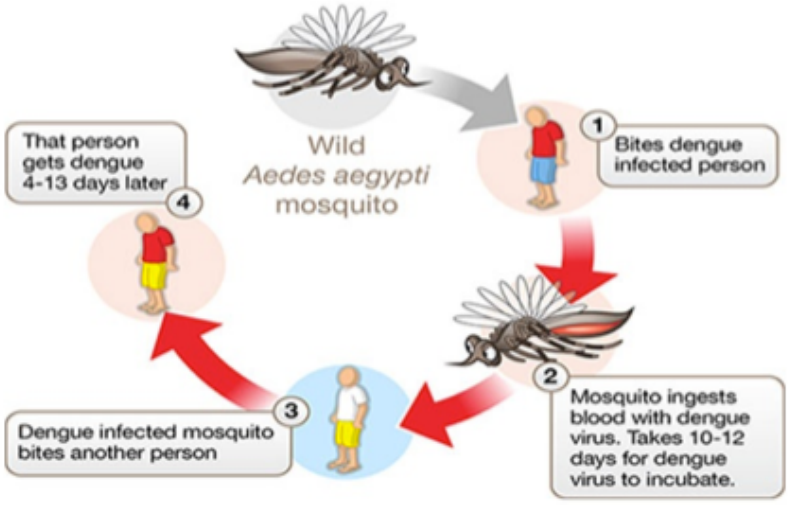


Source: http://www.eastvaleca.gov/residents/northwest-mosquito-and-vector-control

Ecological Relationships of Mosquitoes

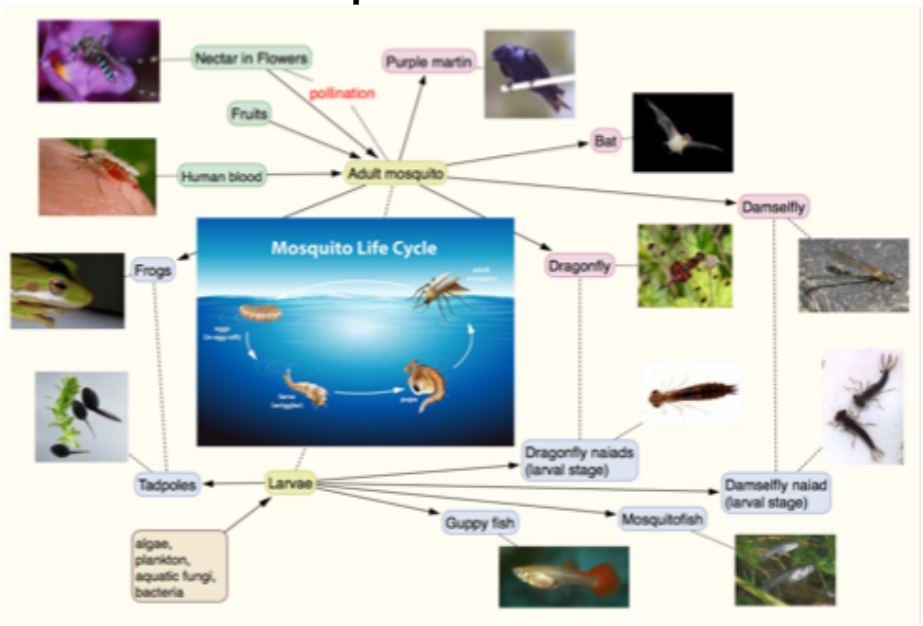
Parasitism	• humans (host) and viruses e.g. Dengue and Zika (parasite)
Predation	• mosquitoes ➔ bats, dragonflies, birds • mosquito larvae ➔ fish, turtles
Mutualism and Symbiosis	• mosquitoes and viruses e.g. Rift Valley fever

Transmission of Dengue Virus

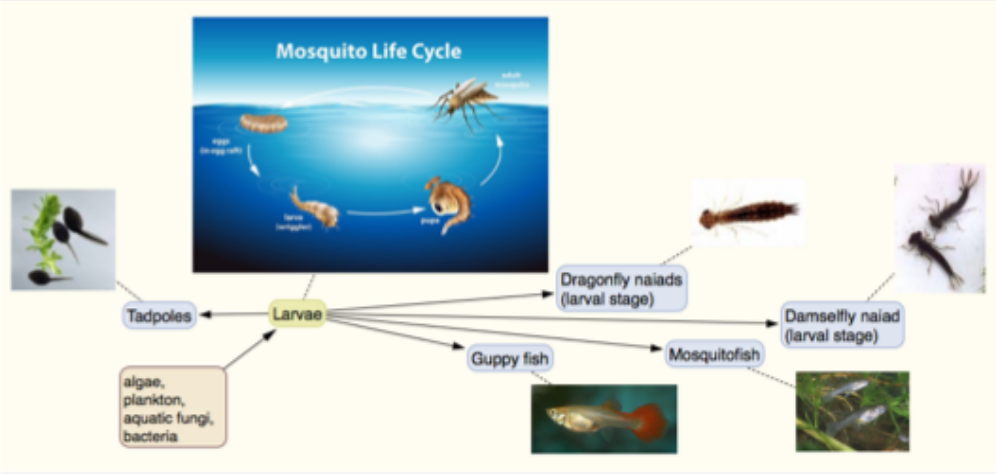


Source: http://www.eliminatedengue.com/our-research/dengue-fever

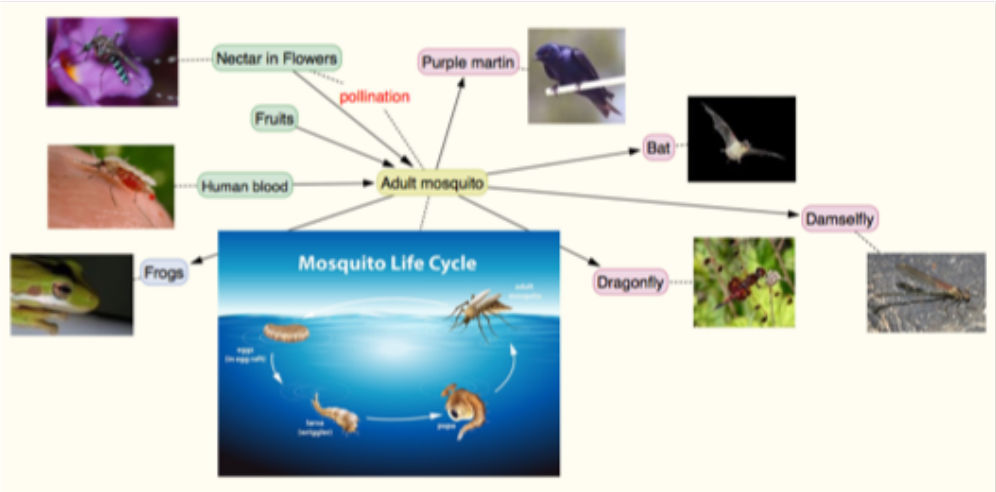
Mosquito Food Web



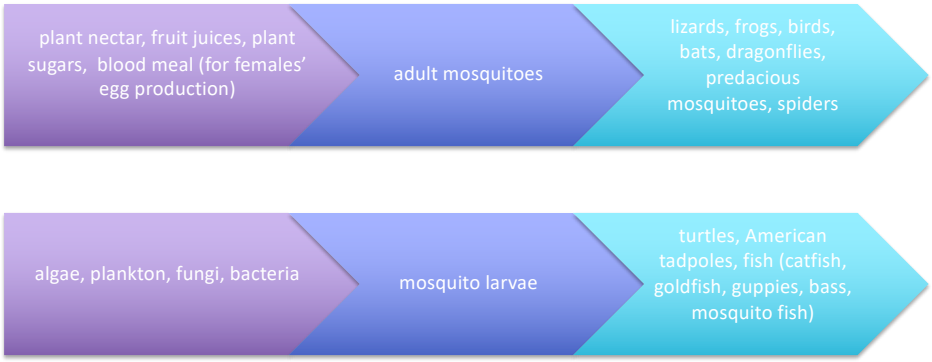
Mosquito Food Web - Aquatic



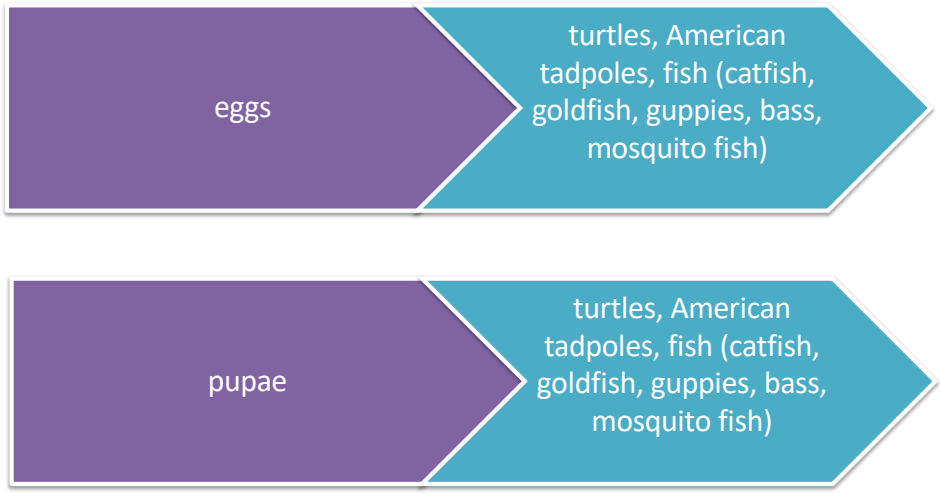
Mosquito Food Web - Terrestrial



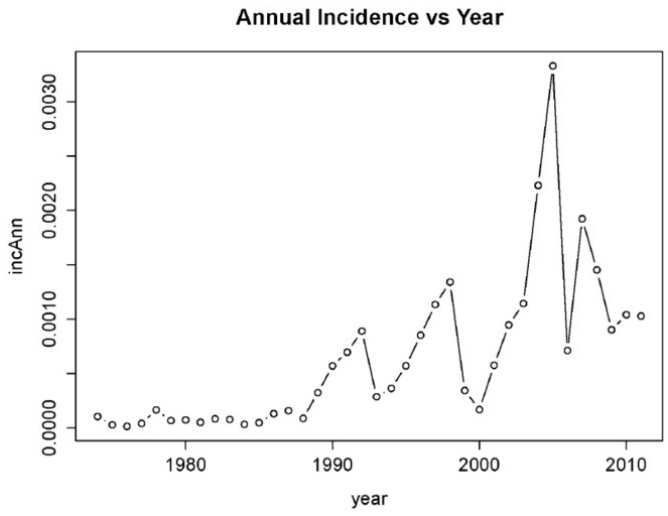
Mosquito Food Chains



Mosquito Food Chains



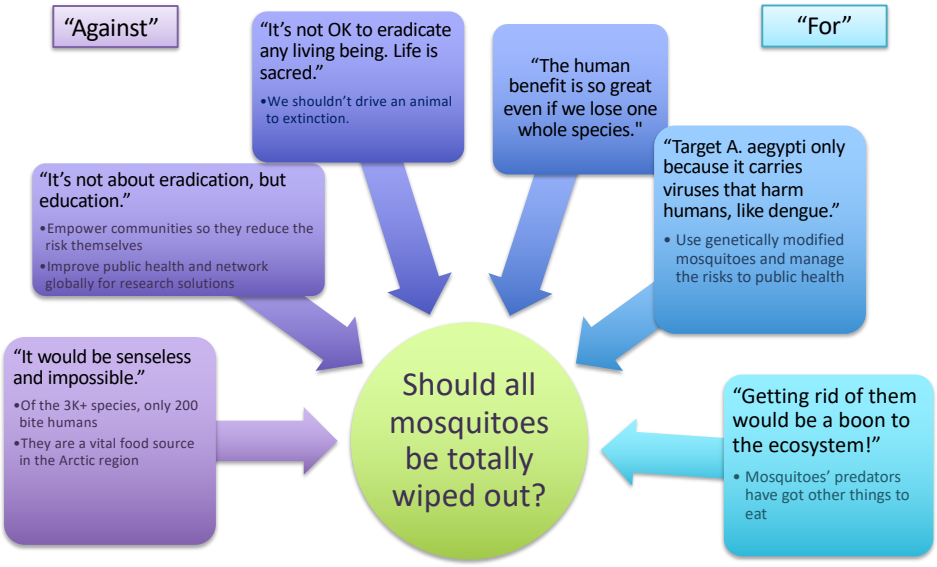
Time series of annual incidence of dengue in Singapore, 1974-2011



Dengue cases in central Singapore

April 2016. Map of dengue cases in the central region of Singapore based on notified dengue cases and mosquito breeding habitats detected in the last 14 days.

Mosquito Population Extermination Debate

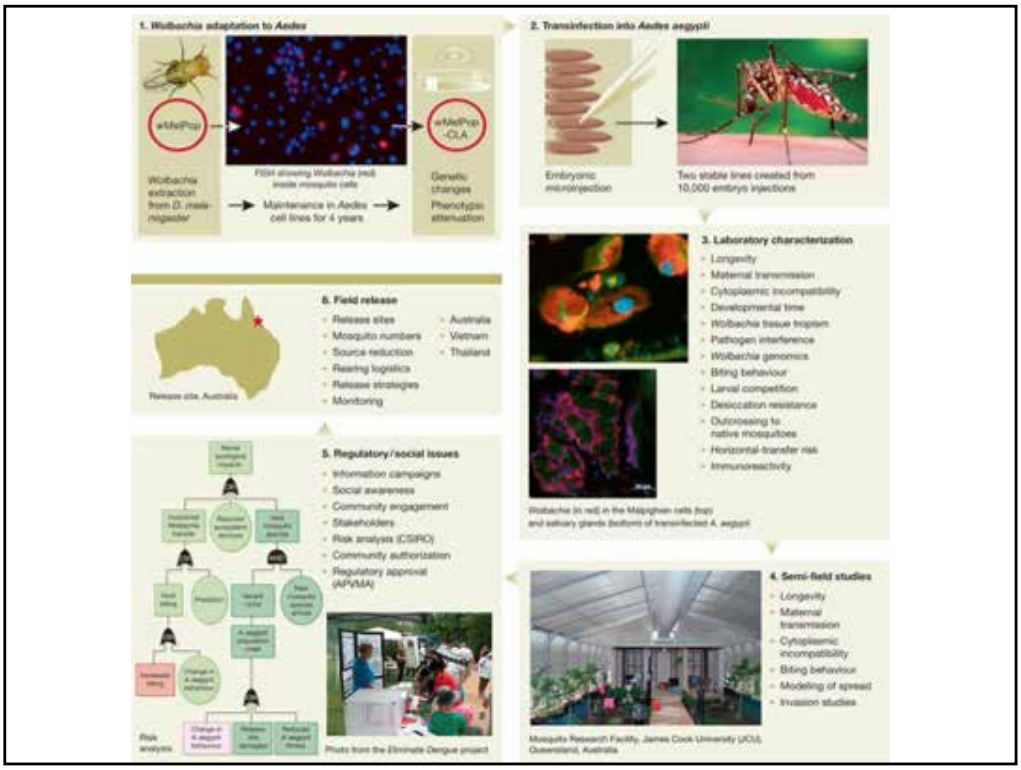


Source: http://www.theguardian.com/global/2016/feb/10/should-we-wipe-mosquitoes-off-the-face-of-the-earth

Fun facts about mosquito

- Mosquitoes are known from as far back as the Triassic Period – 400 million years ago. They are known from North America from the Cretaceous – 100 million years ago.
- There are about 2,700 species of mosquito. There are 176 species in the United States.
- The average mosquito weighs about 2.5 milligrams.
- The average mosquito takes in about 5-millionths of a liter of blood during feeding.
- Mosquitoes find hosts by sight (they observe movement); by detecting infra-red radiation emitted by warm bodies; and by chemical signals (mosquitoes are attracted to carbon dioxide and lactic acid, among other chemicals) at distances of 25 to 35 meters.
- Mosquitoes fly an estimated 1 to 1.5 miles per hour.
- Salt marsh mosquitoes can migrate up to 40 miles for a meal.
- Bigger people are often more attractive to mosquitoes because they are larger targets and they produce more mosquito attractants, namely CO2 and lactic acid.
- Active or fidgety people also produce more CO2 and lactic acid.
- Smelly feet are attractive to certain species of mosquitoes – as is Limburger Cheese.
- Dark clothing has been shown to attract some species of mosquitoes more than lighter colored clothing.
  Movement increased mosquito biting up to 50% in some research tests.
- A full moon increased mosquito activity 500% in one study

Source:
http://www.mosquito.org/fun-facts



Links to Video Resources

1. **WATCH: After first Zika case, MOH, NEA destroy 7 breeding habitats in Watten Estate**

    - **Weblink: http://www.channelnewsasia.com/news/singapore/after-first-zika-case-moh/2784920.html?cid=cna_editorspick_070814**

2. **WATCH: Fishes, dragonfly larvae, and beetle larvae feeding on mosquito larvae**

    - **Weblink https://www.youtube.com/watch?v=8MyL0a1JpvQ**

3. **WATCH: NEA to explore biological control methods to tackle dengue - 15Jun2014**

    - **Weblink https://www.youtube.com/watch?v=csgQLScZyqU**