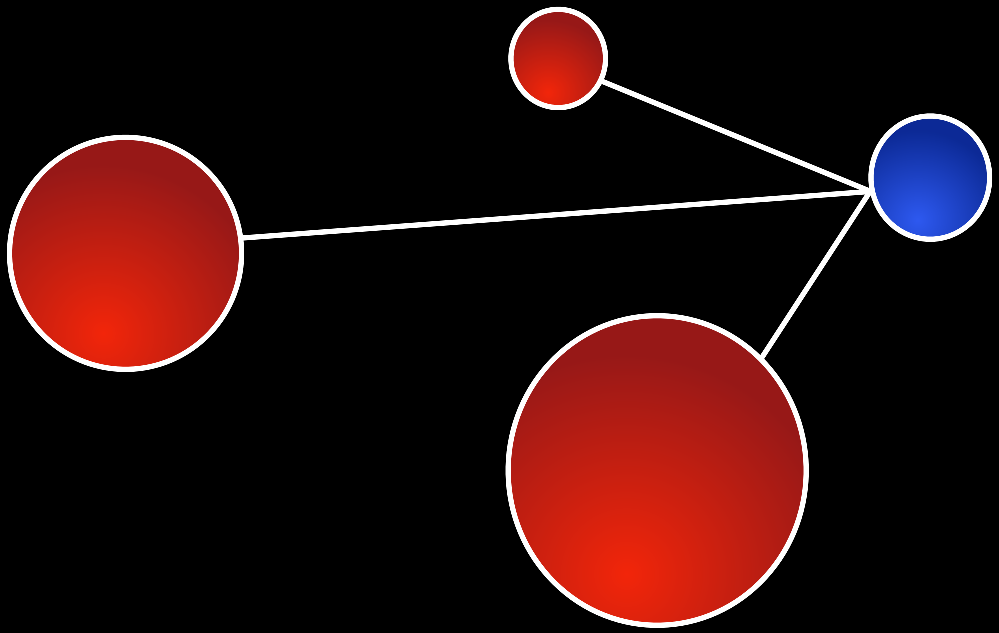


¡VIVA LA EVOLUTION!

(aka, It's An Evolution!)

JOHNNY WINN

(@johnny_rugger)

JOHNNY WINN

(@johnny_rugger)

(host of the Elixir Fountain)

(@elixirfountain)

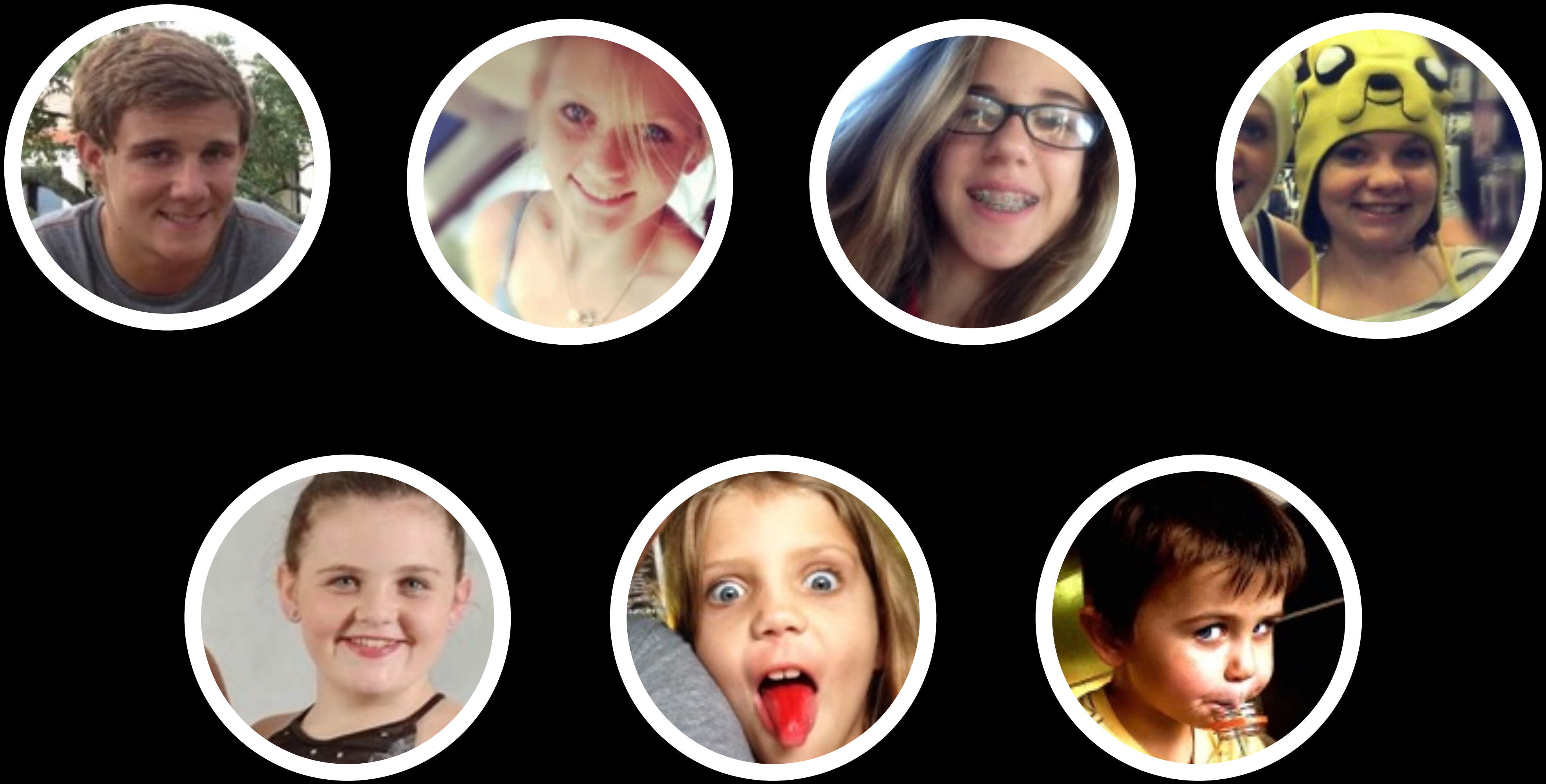
¡DISCLAIMER!

(I am NOT a geneticist)

¡DISCLAIMER!

(I am NOT a geneticist)

(I don't even play one on TV)



WHAT?

(BRIEF) HISTORY OF THE THEORY OF EVOLUTION

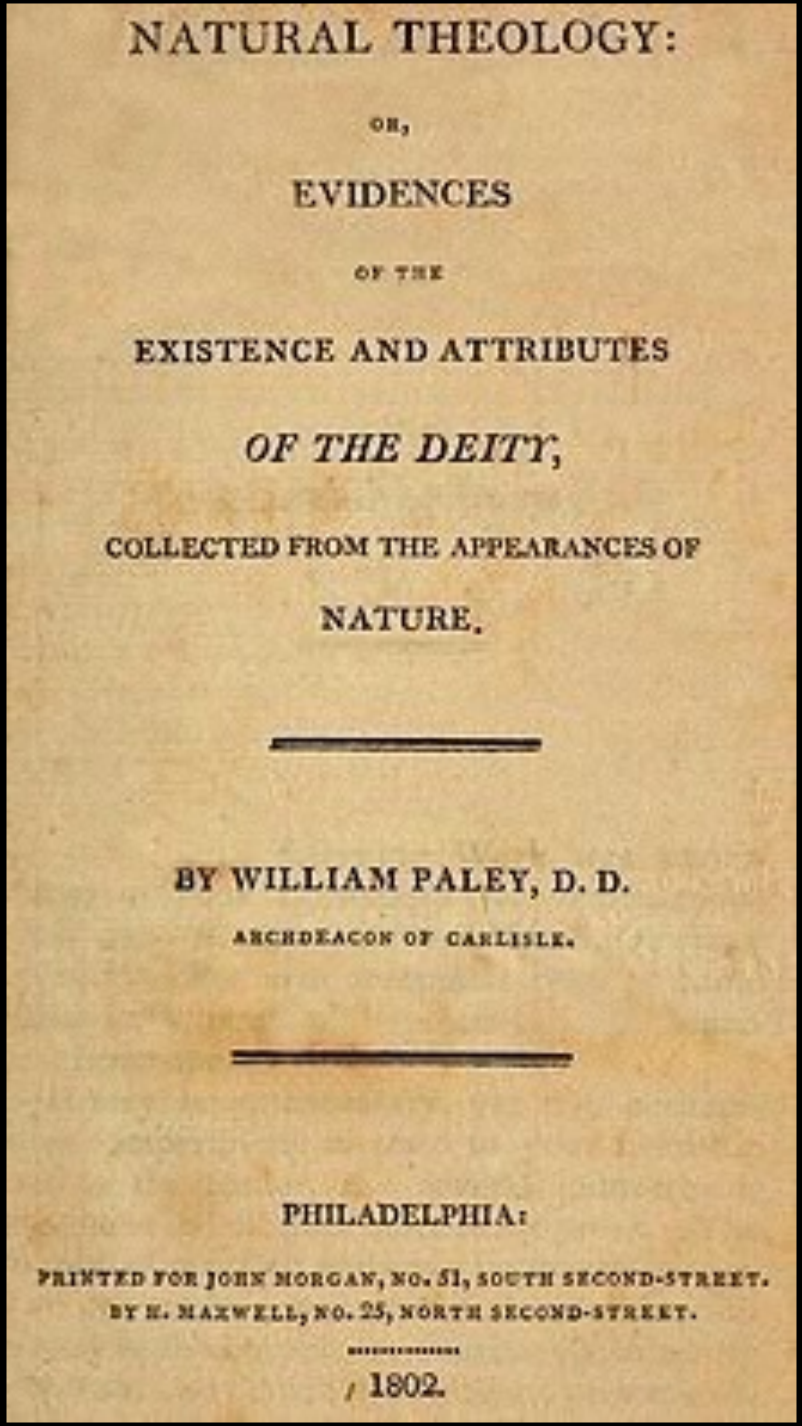
(SIMPLE) GENETICS

BUILD (THINGS)

¡EVOLUTION DISCOVERED!

(in 1831)

(William Paley)


NATURAL THEOLOGY:

OR,

EVIDENCES

OF THE

EXISTENCE AND ATTRIBUTES

OF THE DEITY,

COLLECTED FROM THE APPEARANCES OF

NATURE.

BY WILLIAM PALEY, D. D.

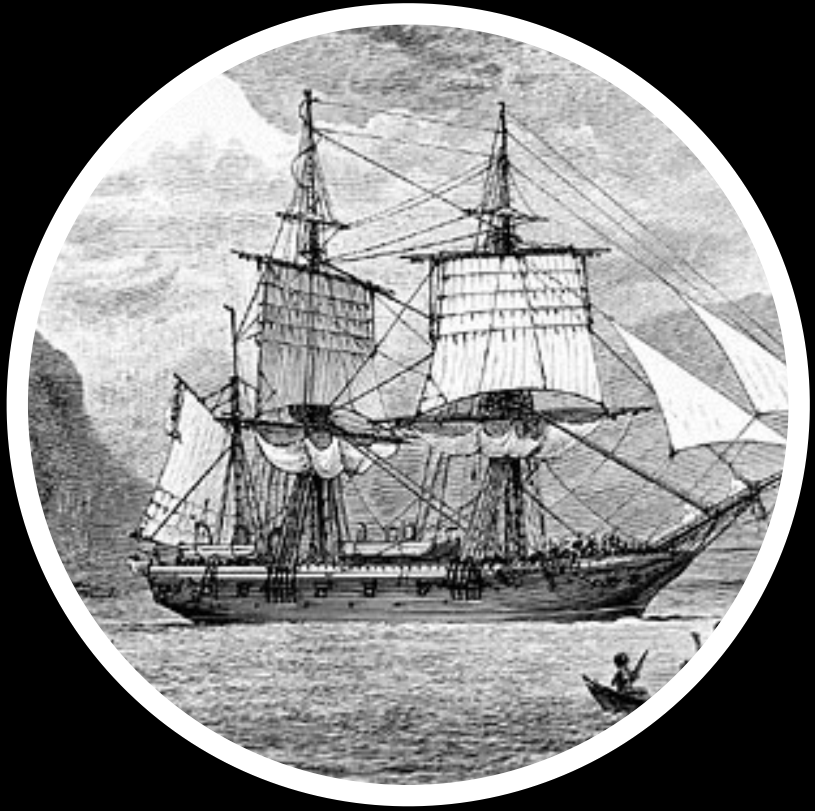
ARCHDEACON OF CARLISLE.

PHILADELPHIA:

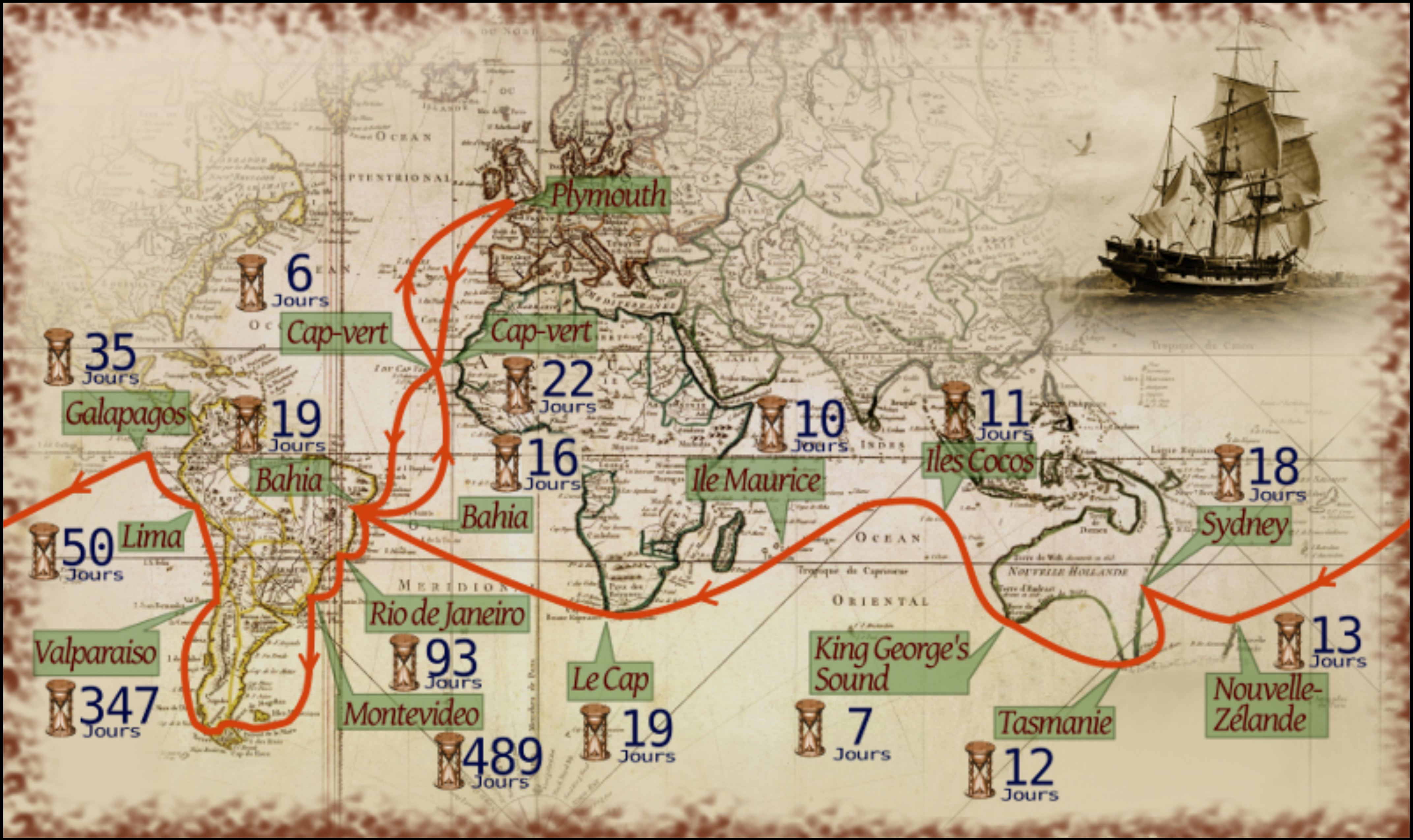
PRINTED FOR JOHN MORGAN, NO. 51, SOUTH SECOND-STREET.
BY H. MAXWELL, NO. 25, NORTH SECOND-STREET.

1802.

(Charles Darwin)

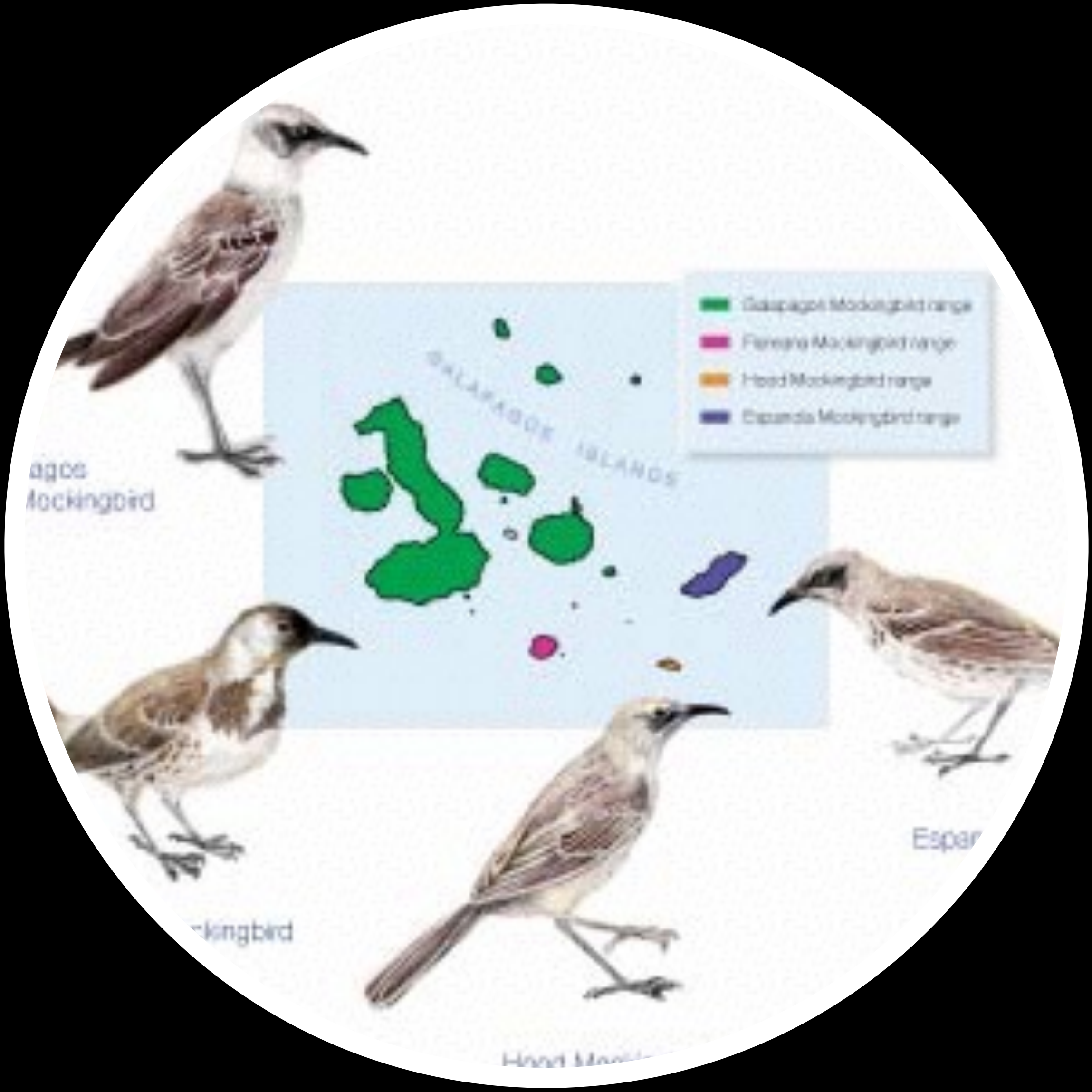


(HMS Beagle)



(feature creep?)

(did someone say 3 hour tour?)


🟩 Galapagos Mockingbird range
🟪 Floreana Mockingbird range
🟧 Hood Mockingbird range
🟦 Espanola Mockingbird range
GALAPAGOS ISLANDS
agos
Mockingbird
kingbird
Espar
Hood Mocki

(It is not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change.)

~DARWIN

(SIMPLE) GENETICS

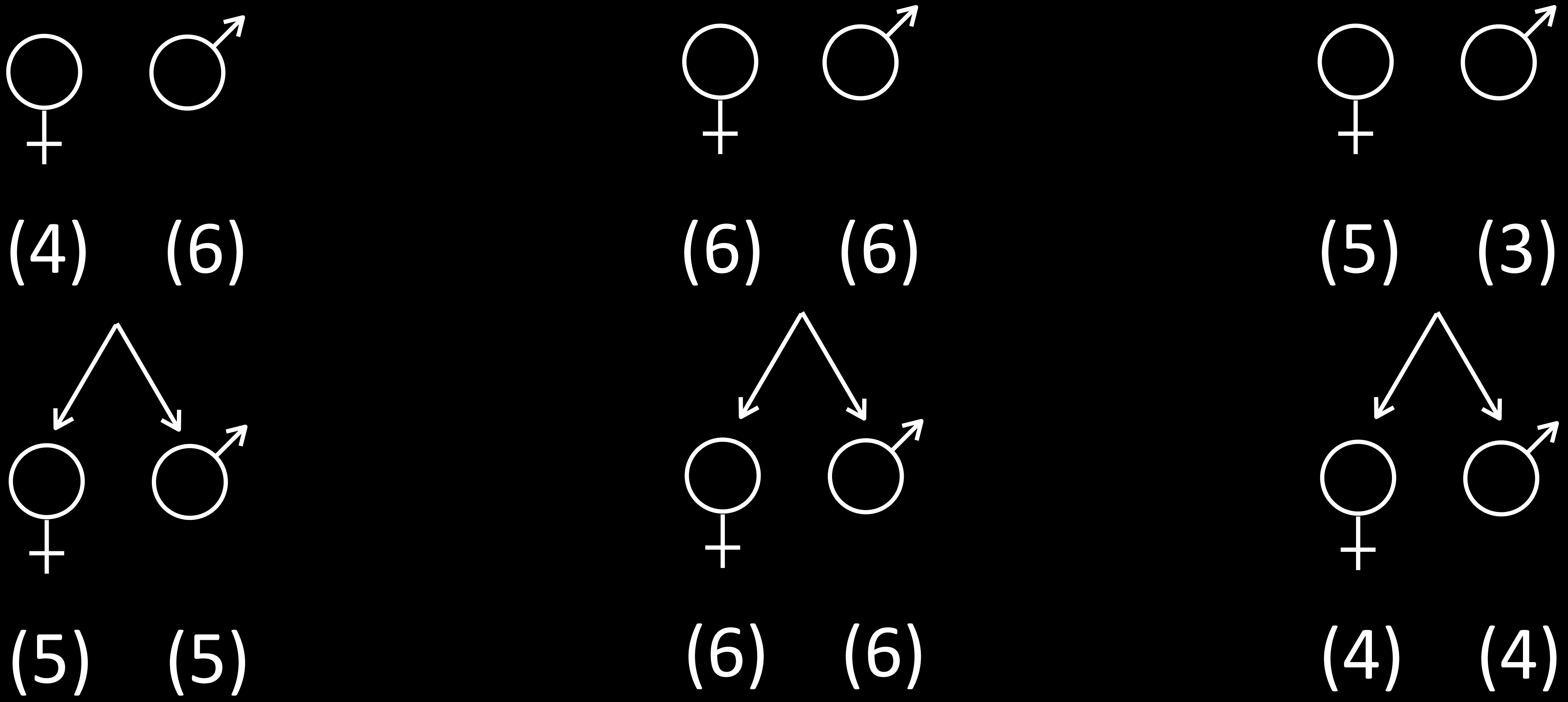
(Gregor Mendel)

(Why pea plants?)

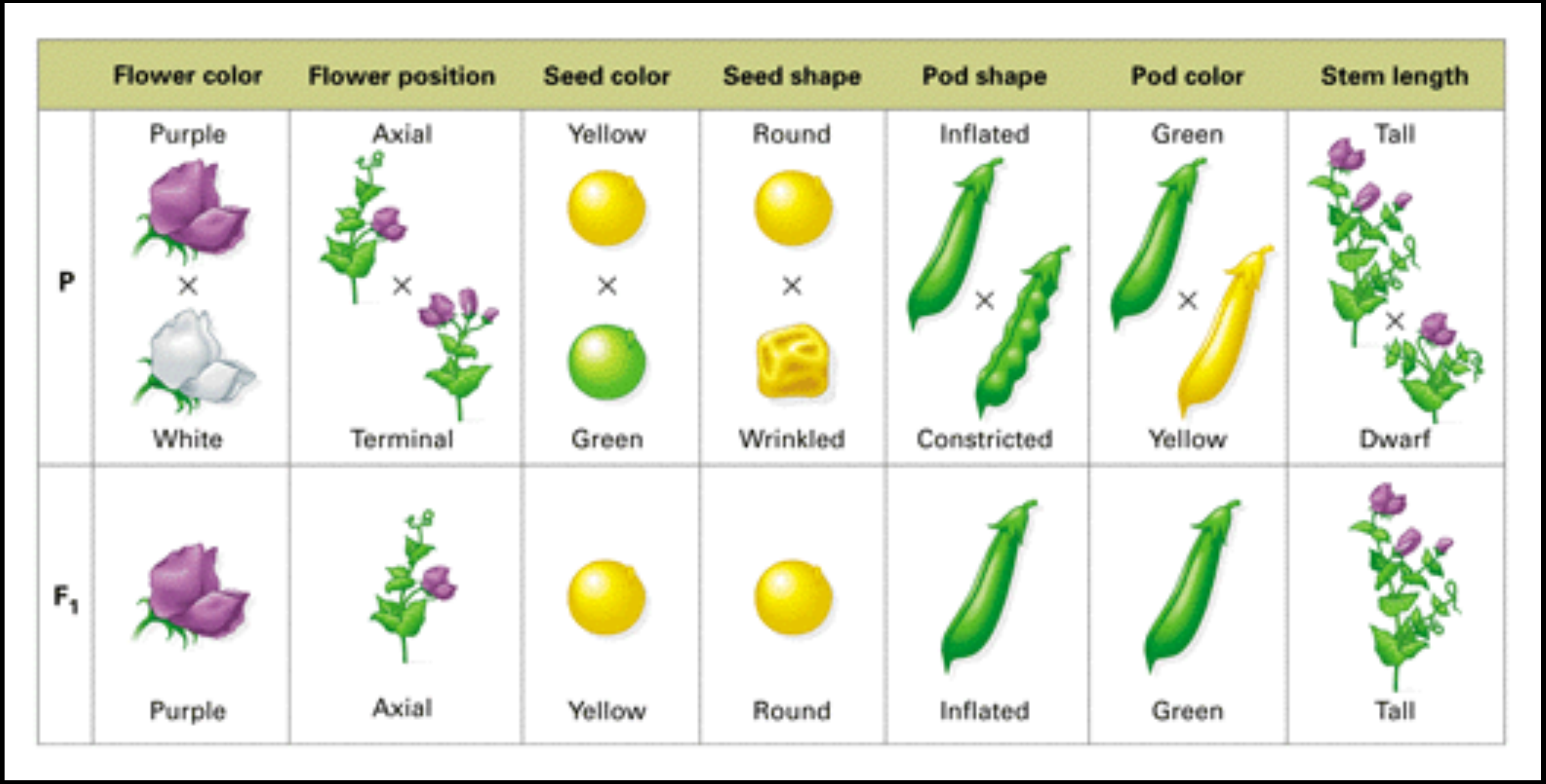
★

♀	♂	♀	♂	♀	♂
(4)	(6)	(6)	(6)	(5)	(3)

(blended inheritance)



(problem with blended inheritance)



	Flower color	Flower position	Seed color	Seed shape	Pod shape	Pod color	Stem length
P	Purple × White	Axial × Terminal	Yellow × Green	Round × Wrinkled	Inflated × Constricted	Green × Yellow	Tall × Dwarf
F_1	Purple	Axial	Yellow	Round	Inflated	Green	Tall

	G	y
G	GG	Gy
y	Gy	yy

(punnet square)

	G	y
G	GG	Gy
y	Gy	yy

(50% Gy, 25% GG, 25% yy)

	G	y
G	GG	Gy
G	GG	Gy

(100% Green!)

	G/T	y/t	G/t	y/T
G/T	GG/TT	Gy/Tt	GG/Tt	Gy/TT
y/T	Gy/TT	yy/Tt	Gy/Tt	yy/TT
G/t	GG/Tt	Gy/tt	GG/tt	Gy/Tt
y/t	Gy/Tt	yy/tt	Gy/tt	yy/Tt

(multiple traits)

	G/T	y/t	G/t	y/T
G/T	GG/TT	Gy/Tt	GG/Tt	Gy/TT
y/T	Gy/TT	yy/Tt	Gy/Tt	yy/TT
G/t	GG/Tt	Gy/tt	GG/tt	Gy/Tt
y/t	Gy/Tt	yy/tt	Gy/tt	yy/Tt

(56% Green/Tall, 19% Yellow/Tall, 19% Yellow/Short, 6% Yellow Short)

3 LAWS OF INHERITANCE

(Law of Segregation)

3 LAWS OF INHERITANCE

(Law of Segregation)

(Law of Independent Assortment)

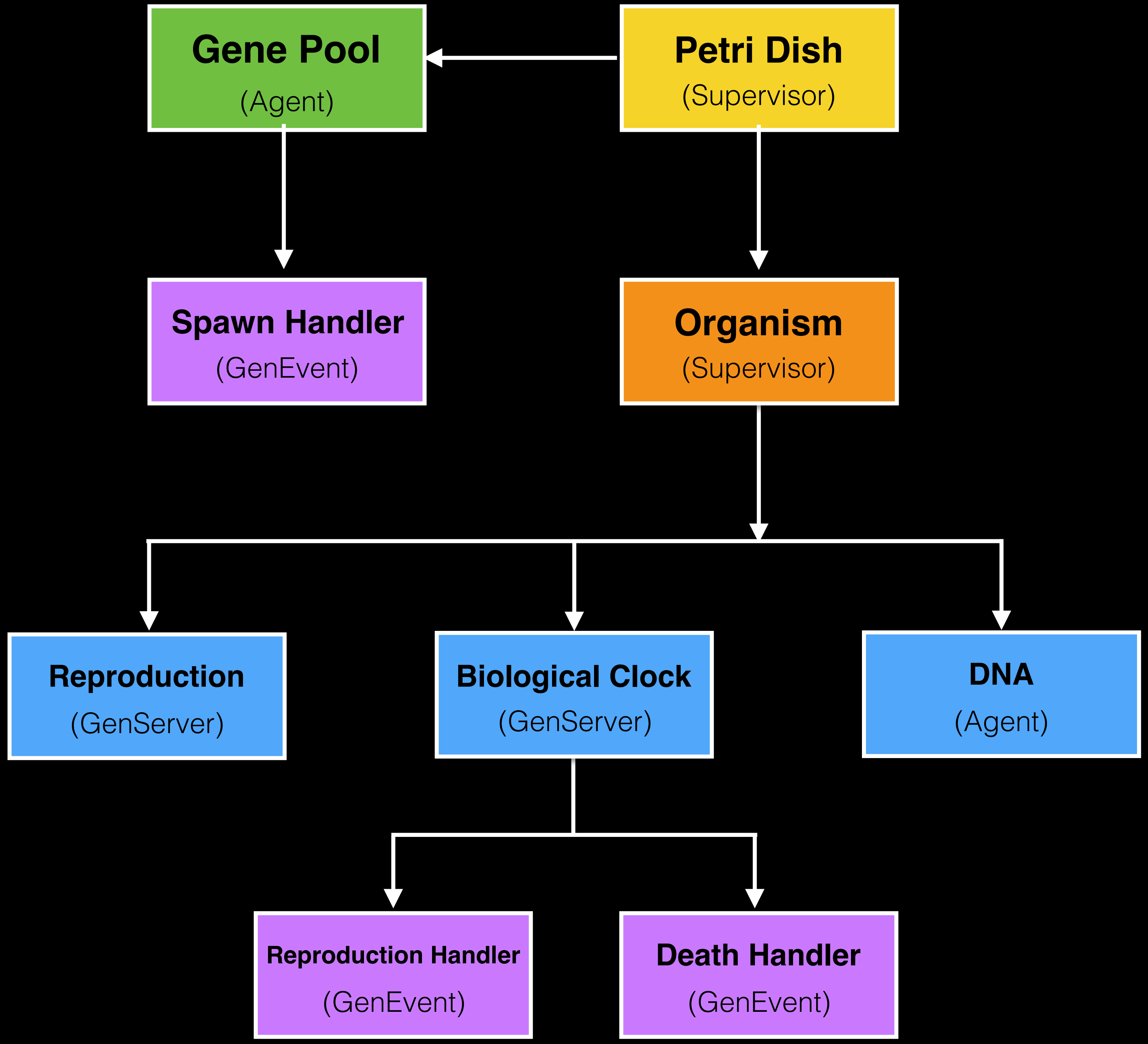
3 LAWS OF INHERITANCE

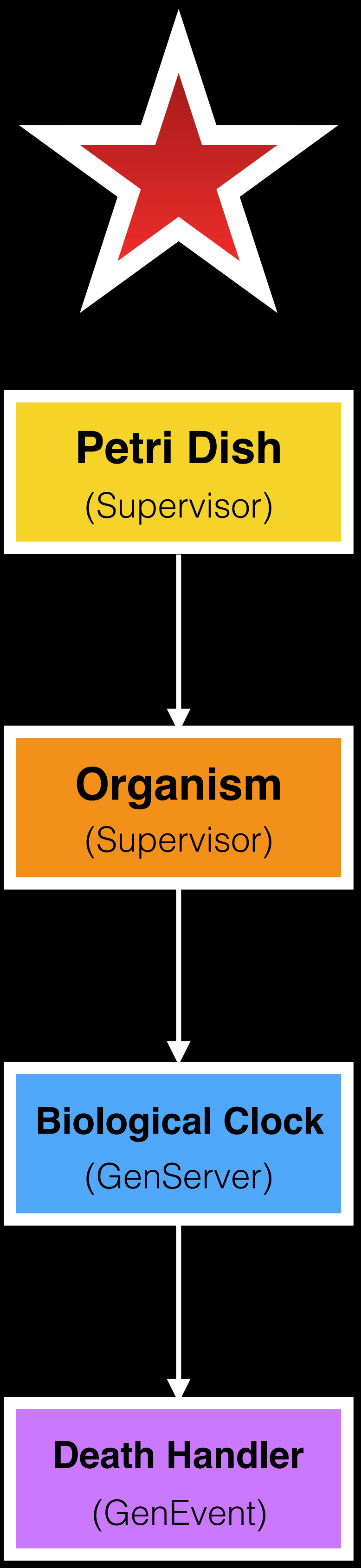
(Law of Segregation)

(Law of Independent Assortment)

(Law of Dominance)

BUILD (THINGS)


Gene Pool
(Agent)
Petri Dish
(Supervisor)
Spawn Handler
(GenEvent)
Organism
(Supervisor)
Reproduction
(GenServer)
Biological Clock
(GenServer)
DNA
(Agent)
Reproduction Handler
(GenEvent)
Death Handler
(GenEvent)


Petri Dish
(Supervisor)
Organism
(Supervisor)
Biological Clock
(GenServer)
Death Handler
(GenEvent)

```elixir
defmodule Darwin.PetriDish do
  use Supervisor

  alias Darwin.Organism
  alias Darwin.DeathHandler

  @moduledoc "The petri dish is where a collection of organisms live"

  def start_link,
    do: Supervisor.start_link(__MODULE__, nil, name: __MODULE__)

  def init(_opts) do
    register_bio_events()

    children = [
      supervisor(Organism, [], restart: :transient)
    ]

    supervise(children, [strategy: :simple_one_for_one])
  end

  def new_organism([x, y]) do
    Supervisor.start_child(__MODULE__, [%{gametes: [x, y]}])
    GenEvent.notify(:darwin, {:new_organism, [x, y]})
  end

  def kill_organism(organism),
    do: Supervisor.terminate_child(__MODULE__, organism.pid)

  defp register_bio_events do
    GenEvent.start_link(name: :bio_events)
    :ok = GenEvent.add_mon_handler(:bio_events, DeathHandler, [])
  end
end
```

```elixir
@process_type "organism"

def start_link(%{gametes: [_x, _y]} = gametes) do
  organism = create_organism(gametes)

  Supervisor.start_link(__MODULE__, organism, name: organism.name)
end

def init(organism) do
  organism = %{organism | pid: self}

  children = [
    worker(Organism.BiologicalClock, [{:organism, organism}]),
  ]

  supervise(children, [strategy: :one_for_one])
end

defp create_organism(%{gametes: gametes}) do
  gametes
  |> define_organism
  |> name_organism
  |> combine_sizes
  |> combine_colors
  |> combine_speeds
end

defp define_organism(gametes),
  do: %Darwin.Organism{gametes: gametes, birth_time: :erlang.system_time()}

defp name_organism(organism),
  do: %{organism | name: Utils.name_process(@process_type, organism)}

defp combine_colors(%{gametes: [%{color: x}, %{color: y}]} = organism),
  do: %{organism | color: [x, y]}
```

```elixir
defmodule Darwin.Organism do
  use Supervisor

  @moduledoc "A single organism"

  defstruct pid: nil,
            name: nil,
            birth_time: nil,
            size: ["S", "s"],
            color: ["C", "c"],
            speed: ["F", "f"],
            gametes: []

  import Darwin.Organism.Utils

  alias Darwin.Organism.Utils
  alias Darwin.Organism

  @process_type "organism"

  def start_link(%{gametes: [_x, _y]} = gametes) do
    organism = create_organism(gametes)

    Supervisor.start_link(__MODULE__, organism, name: organism.name)
  end

  def init(organism) do
    organism = %{organism | pid: self}

    children = [
      worker(Organism.BiologicalClock, [{:organism, organism}]),
    ]

    supervise(children, [strategy: :one_for_one])
```

```elixir
defmodule Darwin.Organism do
  use Supervisor

  @moduledoc "A single organism"

  defstruct pid: nil,
            name: nil,
            birth_time: nil,
            size: ["S", "s"],
            color: ["C", "c"],
            speed: ["F", "f"],
            gametes: []

  import Darwin.Organism.Utils

  alias Darwin.Organism.Utils
  alias Darwin.Organism

  @process_type "organism"

  def start_link(%{gametes: [_x, _y]} = gametes) do
    organism = create_organism(gametes)

    Supervisor.start_link(__MODULE__, organism, name: organism.name)
  end

  def init(organism) do
    organism = %{organism | pid: self}

    children = [
      worker(Organism.BiologicalClock, [{:organism, organism}]),
    ]

    supervise(children, [strategy: :one_for_one])
```

```elixir
def init(organism) do
  organism = %{organism | pid: self}

  children = [
    worker(Organism.BiologicalClock, [{:organism, organism}]),
  ]

  supervise(children, [strategy: :one_for_one])
end

defp create_organism(%{gametes: gametes}) do
  gametes
  |> define_organism
  |> name_organism
  |> combine_sizes
  |> combine_colors
  |> combine_speeds
end

defp define_organism(gametes),
  do: %Darwin.Organism{gametes: gametes, birth_time: :erlang.system_time()}

defp name_organism(organism),
  do: %{organism | name: Utils.name_process(@process_type, organism)}

defp combine_colors(%{gametes: [%{color: x}, %{color: y}]} = organism),
  do: %{organism | color: [x, y]}

defp combine_speeds(%{gametes: [%{speed: x}, %{speed: y}]} = organism),
  do: %{organism | speed: [x, y]}

defp combine_sizes(%{gametes: [%{size: x}, %{size: y}]} = organism),
  do: %{organism | size: [x, y]}
```

```elixir
def init(organism) do
  organism = %{organism | pid: self}

  children = [
    worker(Organism.BiologicalClock, [{:organism, organism}]),
  ]

  supervise(children, [strategy: :one_for_one])
end

defp create_organism(%{gametes: gametes}) do
  gametes
  |> define_organism
  |> name_organism
  |> combine_sizes
  |> combine_colors
  |> combine_speeds
end
```

```elixir
defp define_organism(gametes),
  do: %Darwin.Organism{gametes: gametes, birth_time: :erlang.system_time()}

defp name_organism(organism),
  do: %{organism | name: Utils.name_process(@process_type, organism)}

defp combine_colors(%{gametes: [%{color: x}, %{color: y}]} = organism),
  do: %{organism | color: [x, y]}

defp combine_speeds(%{gametes: [%{speed: x}, %{speed: y}]} = organism),
  do: %{organism | speed: [x, y]}

defp combine_sizes(%{gametes: [%{size: x}, %{size: y}]} = organism),
  do: %{organism | size: [x, y]}
```

```elixir
@process_type "bio_clock"

def start_link({:organism, organism}),
  do: GenServer.start_link(__MODULE__, organism, name: process_name(organism))

def init(organism) do
  send(self, {:start_biological_clock})

  Process.send_after(self, {:death}, :random.uniform(20000))

  {:ok, organism}
end

def handle_info({:start_biological_clock}, organism),
  do: biological_clock(organism)

def handle_info({:death}, organism),
  do: death(organism)

def handle_info({:reproduce}, organism),
  do: reproduce(organism)

defp death(organism) do
  GenEvent.notify(:bio_events, {:death, organism})
  {:noreply, organism}
end

defp process_name(organism),
  do: Utils.name_process(@process_type, organism)
```

```elixir
@process_type "bio_clock"

def start_link({:organism, organism}),
  do: GenServer.start_link(__MODULE__, organism, name: process_name(organism))

def init(organism) do
  send(self, {:start_biological_clock})

  Process.send_after(self, {:death}, :random.uniform(20000))

  {:ok, organism}
end

def handle_info({:start_biological_clock}, organism),
  do: biological_clock(organism)

def handle_info({:death}, organism),
  do: death(organism)

def handle_info({:reproduce}, organism),
  do: reproduce(organism)

defp death(organism) do
  GenEvent.notify(:bio_events, {:death, organism})
  {:noreply, organism}
end

defp process_name(organism),
  do: Utils.name_process(@process_type, organism)
```

```elixir
defmodule Darwin.DeathHandler do
  use GenEvent

  alias Darwin.PetriDish

  def handle_event({:death, organism}, state) do
    PetriDish.kill_organism(organism)
    {:ok, state}
  end

  def handle_event(_event, state),
    do: {:ok, state}

end
```

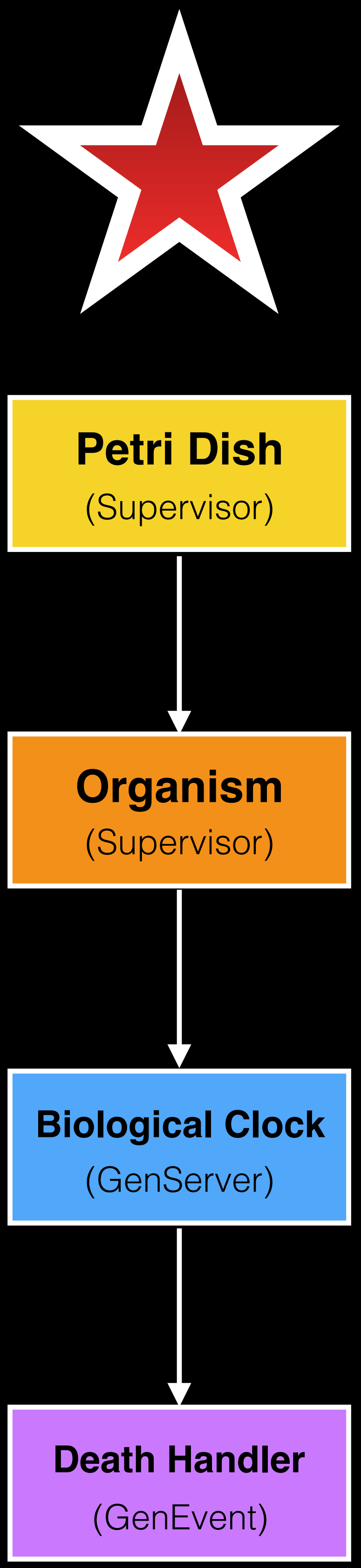
(Petri Dish)

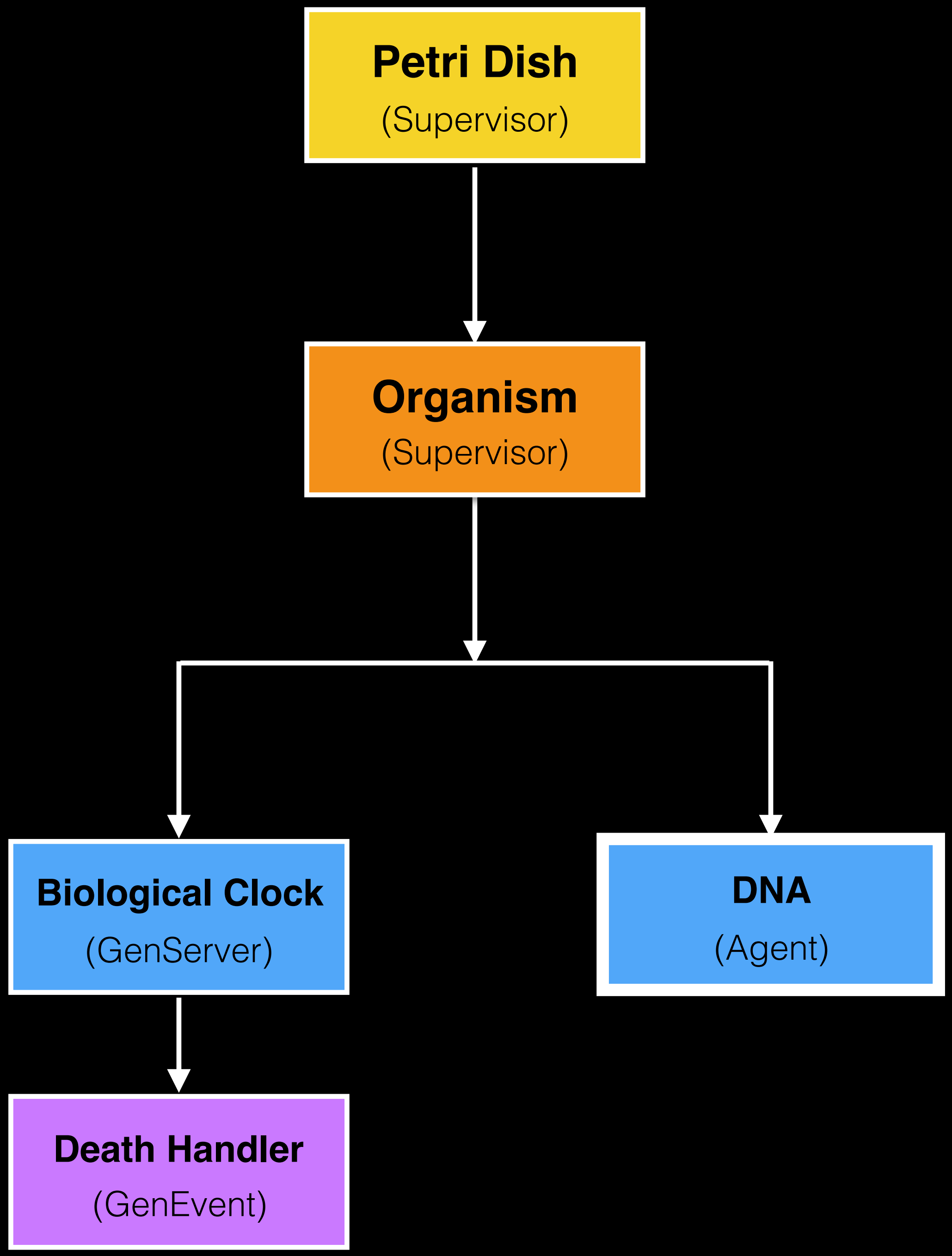
```elixir
def new_organism([x, y]) do
  Supervisor.start_child(__MODULE__, [%{gametes: [x, y]}])
  GenEvent.notify(:darwin, {:new_organism, [x, y]})
end

def kill_organism(organism),
  do: Supervisor.terminate_child(__MODULE__, organism.pid)

defp register_bio_events do
  GenEvent.start_link(name: :bio_events)

  :ok = GenEvent.add_mon_handler(:bio_events, ReproductionHandler, [])
  :ok = GenEvent.add_mon_handler(:bio_events, DeathHandler, [])
  :ok = GenEvent.add_mon_handler(:bio_events, SpawnHandler, [])
end
```

```elixir
defmodule Darwin.DeathHandler do
  use GenEvent

  alias Darwin.PetriDish

  def handle_event({:death, organism}, state) do
    PetriDish.kill_organism(organism)
    {:ok, state}
  end

  def handle_event(_event, state),
    do: {:ok, state}

end
```

(Petri Dish)

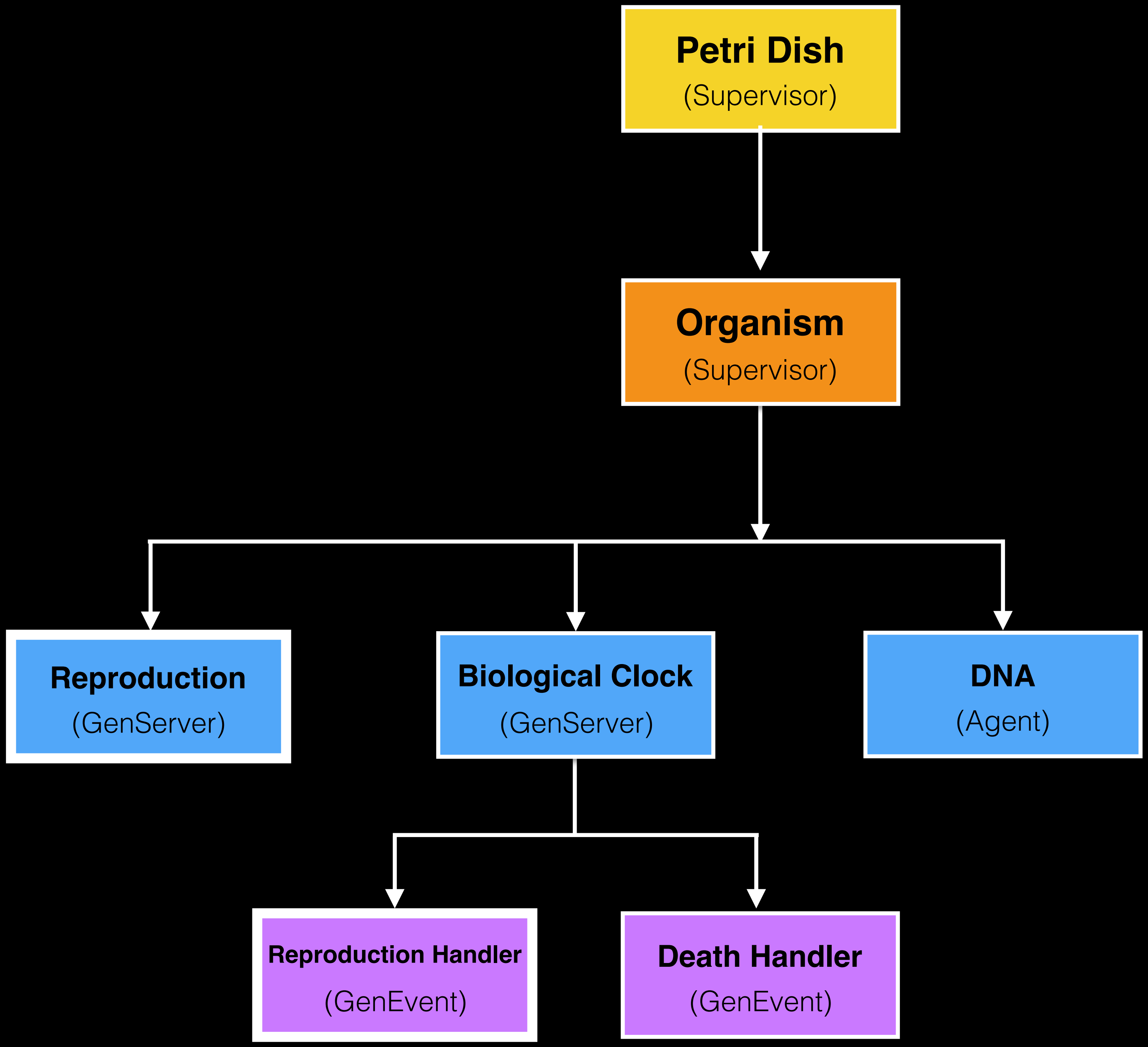
```elixir
def new_organism([x, y]) do
  Supervisor.start_child(__MODULE__, [%{gametes: [x, y]}])
  GenEvent.notify(:darwin, {:new_organism, [x, y]})
end

def kill_organism(organism),
  do: Supervisor.terminate_child(__MODULE__, organism.pid)

defp register_bio_events do
  GenEvent.start_link(name: :bio_events)

  :ok = GenEvent.add_mon_handler(:bio_events, ReproductionHandler, [])
  :ok = GenEvent.add_mon_handler(:bio_events, DeathHandler, [])
  :ok = GenEvent.add_mon_handler(:bio_events, SpawnHandler, [])
end
```


Petri Dish
(Supervisor)
Organism
(Supervisor)
Biological Clock
(GenServer)
Death Handler
(GenEvent)


Petri Dish
(Supervisor)
Organism
(Supervisor)
Biological Clock
(GenServer)
DNA
(Agent)
Death Handler
(GenEvent)

```elixir
@process_type "dna"

def start_link(%Darwin.Organism{} = organism),
  do: Agent.start_link(fn -> organism end, name: process_name(organism))

def gamete(organism) do
  organism
  |> process_name
  |> Agent.get(&retrieve_gamete/1)
end

def dna(organism) do
  organism
  |> process_name
  |> Agent.get(fn(%{color: color, speed: speed, size: size}) ->
      %{color: join_pairs(color), speed: join_pairs(speed), size: join_pairs(size)}
    end)
end

defp retrieve_gamete(%{color: color, speed: speed, size: size}),
  do: %{color: split_pairs(color), speed: split_pairs(speed), size: split_pairs(size)}

defp split_pairs(phenotypes),
  do: Enum.random(phenotypes)

defp join_pairs(phenotypes),
  do: Enum.join(phenotypes)

defp process_name(organism),
  do: Utils.name_process(@process_type, organism)
```

```elixir
@process_type "dna"

def start_link(%Darwin.Organism{} = organism),
  do: Agent.start_link(fn -> organism end, name: process_name(organism))

def gamete(organism) do
  organism
  |> process_name
  |> Agent.get(&retrieve_gamete/1)
end

def dna(organism) do
  organism
  |> process_name
  |> Agent.get(fn(%{color: color, speed: speed, size: size}) ->
      %{color: join_pairs(color), speed: join_pairs(speed), size: join_pairs(size)}
    end)
end

defp retrieve_gamete(%{color: color, speed: speed, size: size}),
  do: %{color: split_pairs(color), speed: split_pairs(speed), size: split_pairs(size)}

defp split_pairs(phenotypes),
  do: Enum.random(phenotypes)

defp join_pairs(phenotypes),
  do: Enum.join(phenotypes)

defp process_name(organism),
  do: Utils.name_process(@process_type, organism)
```


Petri Dish
(Supervisor)
Organism
(Supervisor)
Reproduction
(GenServer)
Biological Clock
(GenServer)
DNA
(Agent)
Reproduction Handler
(GenEvent)
Death Handler
(GenEvent)

```elixir
def handle_info({:start_biological_clock}, organism),
  do: biological_clock(organism)

def handle_info({:death}, organism),
  do: death(organism)

def handle_info({:reproduce}, organism),
  do: reproduce(organism)

defp biological_clock(%{speed: ["F", "F"]} = organism) do
  Process.send_after(self, {:reproduce}, :random.uniform(2500))
  {:noreply, organism}
end

defp biological_clock(%{speed: ["f", "f"]} = organism) do
  Process.send_after(self, {:reproduce}, :random.uniform(7500))
  {:noreply, organism}
end

defp biological_clock(organism) do
  Process.send_after(self, {:reproduce}, :random.uniform(5000))
  {:noreply, organism}
end

defp death(organism) do
  GenEvent.notify(:bio_events, {:death, organism})
  {:noreply, organism}
end

defp reproduce(organism) do
  GenEvent.notify(:bio_events, {:reproduce, organism})
  biological_clock(organism)
end
```

```elixir
def handle_info({:start_biological_clock}, organism),
  do: biological_clock(organism)

def handle_info({:death}, organism),
  do: death(organism)

def handle_info({:reproduce}, organism),
  do: reproduce(organism)

defp biological_clock(%{speed: ["F", "F"]} = organism) do
  Process.send_after(self, {:reproduce}, :random.uniform(2500))
  {:noreply, organism}
end

defp biological_clock(%{speed: ["f", "f"]} = organism) do
  Process.send_after(self, {:reproduce}, :random.uniform(7500))
  {:noreply, organism}
end

defp biological_clock(organism) do
  Process.send_after(self, {:reproduce}, :random.uniform(5000))
  {:noreply, organism}
end

defp death(organism) do
  GenEvent.notify(:bio_events, {:death, organism})
  {:noreply, organism}
end

defp reproduce(organism) do
  GenEvent.notify(:bio_events, {:reproduce, organism})
  biological_clock(organism)
end
```

```elixir
defmodule Darwin.ReproductionHandler do
  use GenEvent

  alias Darwin.GenePool
  alias Darwin.Organism.DNA

  def handle_event({:reproduce, organism}, state) do
    GenePool.join_pool({organism.pid, DNA.gamete(organism)})
    {:ok, state}
  end

  def handle_event(_event, state),
    do: {:ok, state}

end
```

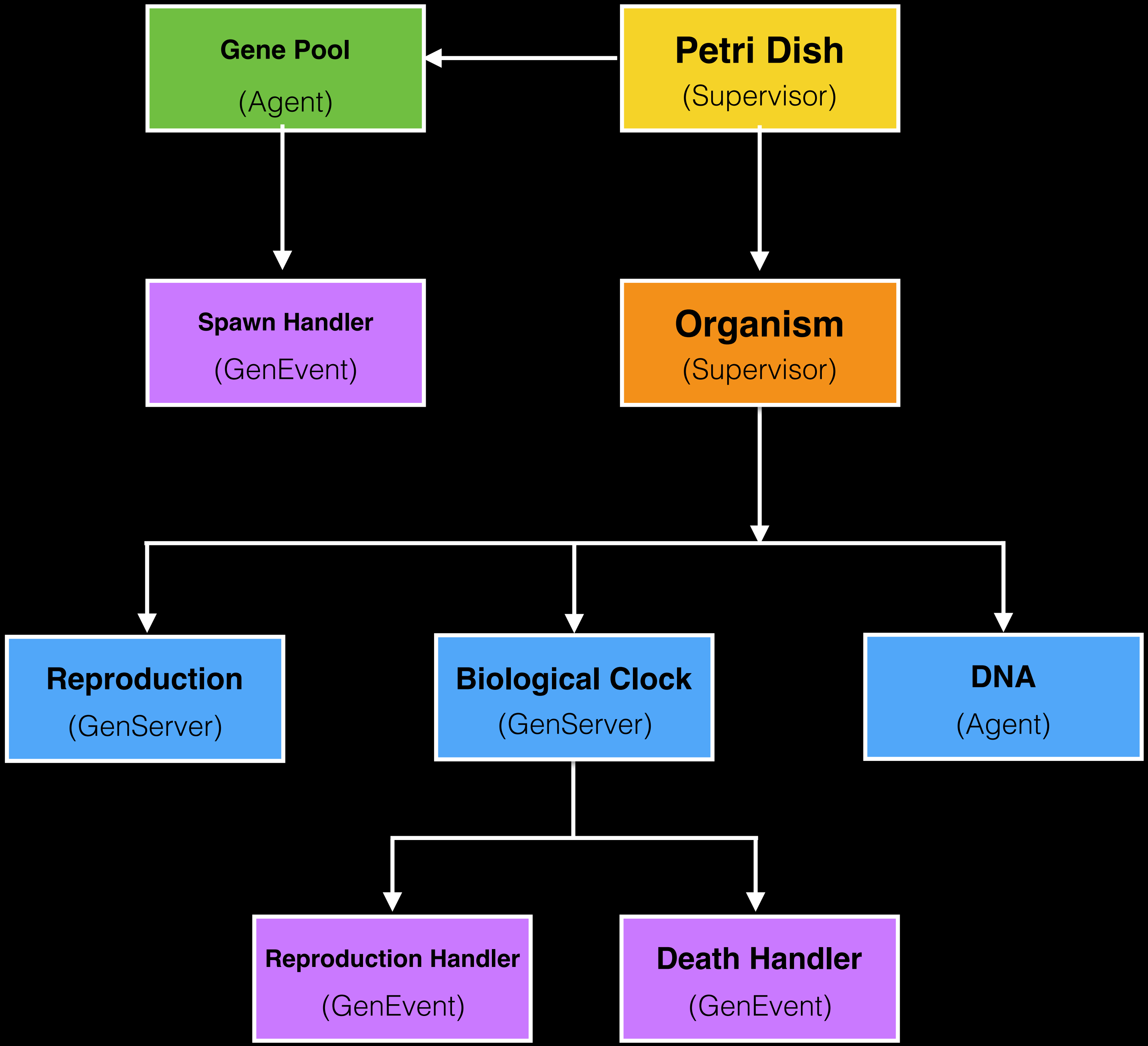
(Petri Dish)

```elixir
def new_organism([x, y]) do
  Supervisor.start_child(__MODULE__, [%{gametes: [x, y]}])
  GenEvent.notify(:darwin, {:new_organism, [x, y]})
end

def kill_organism(organism),
  do: Supervisor.terminate_child(__MODULE__, organism.pid)

defp register_bio_events do
  GenEvent.start_link(name: :bio_events)

  :ok = GenEvent.add_mon_handler(:bio_events, ReproductionHandler, [])
  :ok = GenEvent.add_mon_handler(:bio_events, DeathHandler, [])
end
```

```elixir
defmodule Darwin.ReproductionHandler do
  use GenEvent

  alias Darwin.GenePool
  alias Darwin.Organism.DNA

  def handle_event({:reproduce, organism}, state) do
    GenePool.join_pool({organism.pid, DNA.gamete(organism)})
    {:ok, state}
  end

  def handle_event(_event, state),
    do: {:ok, state}

end
```

(Petri Dish)

```elixir
def new_organism([x, y]) do
  Supervisor.start_child(__MODULE__, [%{gametes: [x, y]}])
  GenEvent.notify(:darwin, {:new_organism, [x, y]})
end

def kill_organism(organism),
  do: Supervisor.terminate_child(__MODULE__, organism.pid)

defp register_bio_events do
  GenEvent.start_link(name: :bio_events)

  :ok = GenEvent.add_mon_handler(:bio_events, ReproductionHandler, [])
  :ok = GenEvent.add_mon_handler(:bio_events, DeathHandler, [])
end
```


Gene Pool
(Agent)
Petri Dish
(Supervisor)
Spawn Handler
(GenEvent)
Organism
(Supervisor)
Reproduction
(GenServer)
Biological Clock
(GenServer)
DNA
(Agent)
Reproduction Handler
(GenEvent)
Death Handler
(GenEvent)

```elixir
defstruct parent: nil,
          gamete: nil

@fitness %{color: "G", speed: "F", size: "T"}

def start_link,
  do: Agent.start_link(fn() -> [] end, name: __MODULE__)

def current_pool,
  do: Agent.get(__MODULE__, fn(pool) -> pool end)

def join_pool({parent, gamete}) do
  check_for_mate
  |> take_action_on_match({parent, gamete})
end

defp check_for_mate,
  do: Agent.get(__MODULE__, &best_match_or_random/1)

defp best_match_or_random([]),
  do: []

defp best_match_or_random(pool),
  do: best_match_or_random(pool, [])

defp best_match_or_random([%Darwin.GenePool{gamete: @fitness} = match | _rest], _acc),
  do: match

defp best_match_or_random([gamete|rest], acc),
  do: best_match_or_random(rest, [gamete|acc])

defp best_match_or_random([], acc),
  do: Enum.random(acc)
```

```elixir
defp check_for_mate,
  do: Agent.get(__MODULE__, &best_match_or_random/1)

defp best_match_or_random([]),
  do: []

defp best_match_or_random(pool),
  do: best_match_or_random(pool, [])

defp best_match_or_random([%Darwin.GenePool{gamete: @fitness} = match | _rest], _acc),
  do: match

defp best_match_or_random([gamete|rest], acc),
  do: best_match_or_random(rest, [gamete|acc])

defp best_match_or_random([], acc),
  do: Enum.random(acc)

defp take_action_on_match([], {parent, gamete}) do
  Agent.update(__MODULE__, fn(pool) ->
    [%Darwin.GenePool{parent: parent, gamete: gamete}|pool]
  end)
end

defp take_action_on_match(%Darwin.GenePool{gamete: y} = mate, {parent, x}) do
  GenEvent.notify(:bio_events, {:spawn_organism, [x, y]})

  Agent.update(__MODULE__, fn(pool) ->
    Enum.filter(pool, &(&1 != mate))
  end)
end
```

```elixir
defp check_for_mate,
  do: Agent.get(__MODULE__, &best_match_or_random/1)

defp best_match_or_random([]),
  do: []

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  end)
end
```

```
defmodule Darwin.SpawnHandler do
  use GenEvent

  alias Darwin.PetriDish

  def handle_event({:spawn_organism, [_x, _y] = gametes}, state) do
    PetriDish.new_organism(gametes)
    {:ok, state}
  end

  def handle_event(_event, state),
    do: {:ok, state}

end
```

(Petri Dish)

```
def new_organism([x, y]) do
  Supervisor.start_child(__MODULE__, [%{gametes: [x, y]}])
  GenEvent.notify(:darwin, {:new_organism, [x, y]})
end

def kill_organism(organism),
  do: Supervisor.terminate_child(__MODULE__, organism.pid)

defp register_bio_events do
  GenEvent.start_link(name: :bio_events)

  :ok = GenEvent.add_mon_handler(:bio_events, ReproductionHandler, [])
  :ok = GenEvent.add_mon_handler(:bio_events, DeathHandler, [])
  :ok = GenEvent.add_mon_handler(:bio_events, SpawnHandler, [])
end
```

```
defmodule Darwin.SpawnHandler do
  use GenEvent

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end
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(Petri Dish)

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(Petri Dish)

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  def new_organism([x, y]) do
    Supervisor.start_child(__MODULE__, [%{gametes: [x, y]}])
    GenEvent.notify(:darwin, {:new_organism, [x, y]})
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    :ok = GenEvent.add_mon_handler(:bio_events, DeathHandler, [])
    :ok = GenEvent.add_mon_handler(:bio_events, SpawnHandler, [])
  end
```

(but does it work?)

```
# Colors Green (G), Yellow (y)
# Size Tall (T), short(t)

x1 = %{color: "G", speed: "f", size: "t"}
y1 = %{color: "y", speed: "F", size: "T"}

Darwin.PetriDish.new_organism [x1, y1]
```

(let’s see it)

```
# Colors Green (G), Yellow (y)
# Size Tall (T), short(t)

x1 = %{color: "G", speed: "f", size: "t"}
y1 = %{color: "y", speed: "F", size: "T"}

x2 = %{color: "y", speed: "F", size: "t"}
y2 = %{color: "G", speed: "f", size: "T"}

x3 = %{color: "G", speed: "f", size: "t"}
y3 = %{color: "G", speed: "F", size: "T"}


Darwin.PetriDish.new_organism [x1, y1]
Darwin.PetriDish.new_organism [x2, y2]
Darwin.PetriDish.new_organism [x3, y3]
```

(more organisms!)

(Gregor Mendel)

(Charles Darwin)

(Gregor Mendel)

(Charles Darwin)

(Robert)

(Joe)

(Mike)

#MYELIXIRSTATUS

(it’s about sharing our discoveries)

SOME MORE LINKS

(genepool6 http://www.swimbots.com/)

(boxcar2d http://boxcar2d.com/)