Physics of Life, Universe and Everything

Igor Bray, John Curtin Distinguished Professor

Director of Theoretical Physics
Head, Physics and Astronomy
Curtin University Perth, Western Australia

Outline

1. Physics of Life, Universe and Everything
   - Where do Laws come from?
   - Physics-Biology tension
   - Equilibrium: stable or unstable
   - Individual-Society balance
   - Physics culture good for Life
2. Questions and Discussion

Physics of Life, Universe and Everything

Where do Laws come from?

- Emmy Noether, 1918: Laws of Physics come from symmetry principles
  - Conservation of momentum $\Longleftrightarrow$ space is symmetric
  - Symmetry breaking $\Longleftrightarrow$ external forces
- Laws of Life come from symmetry principles too
  - Do unto others as you would have others do unto you
  - Cultural choice:
    - Active symmetry breaking requires force
    - “Power corrupts, absolute power corrupts absolutely”
    - Natural symmetry breaking: “fittest survive”
    - “Civilisation is three missed meals from barbarism”
  - Bad culture: good people do bad things

Curtin University

Physics of Life, Universe and Everything

Where do Laws come from?

- Emmy Noether, 1918: Laws of Physics come from symmetry principles
  - Conservation of momentum $\Longleftrightarrow$ space is symmetric
  - Symmetry breaking $\Longleftrightarrow$ external forces
- Laws of Life come from symmetry principles too
  - Do unto others as you would have others do unto you
  - Cultural choice:
    - Active symmetry breaking requires force
    - “Power corrupts, absolute power corrupts absolutely”
    - Natural symmetry breaking: “fittest survive”
    - “Civilisation is three missed meals from barbarism”
  - Bad culture: good people do bad things

Curtin University

Physics of Life, Universe and Everything

Where do Laws come from?

- Emmy Noether, 1918: Laws of Physics come from symmetry principles
  - Conservation of momentum $\Longleftrightarrow$ space is symmetric
  - Symmetry breaking $\Longleftrightarrow$ external forces
- Laws of Life come from symmetry principles too
  - Do unto others as you would have others do unto you
  - Cultural choice:
    - Active symmetry breaking requires force
    - “Power corrupts, absolute power corrupts absolutely”
    - Natural symmetry breaking: “fittest survive”
    - “Civilisation is three missed meals from barbarism”
  - Bad culture: good people do bad things

Curtin University

Physics-Biology tension

- Physics: Entropy increases, information decreases
  - Destruction is easy; Building is hard
- Biology fights entropy increase: multigenerational
  - Life is about paying it forward $\Rightarrow$ enlightenment
  - Our children are more important than ourselves
  - Action: good; Inaction: bad (neglect, ignore)
- Robert Pirsig's evolutionary hierarchy of Quality
  1. Intellectual (least entropy, maximum information)
  2. Social
  3. Biological
  4. Physical (most entropy, minimum information)
- Applications: health, mutual care, free speech

Curtin University

Physics-Biology tension

- Physics: Entropy increases, information decreases
  - Destruction is easy; Building is hard
- Biology fights entropy increase: multigenerational
  - Life is about paying it forward $\Rightarrow$ enlightenment
  - Our children are more important than ourselves
  - Action: good; Inaction: bad (neglect, ignore)
- Robert Pirsig's evolutionary hierarchy of Quality
  1. Intellectual (least entropy, maximum information)
  2. Social
  3. Biological
  4. Physical (most entropy, minimum information)
- Applications: health, mutual care, free speech

Curtin University

Physics-Biology tension

- Physics: Entropy increases, information decreases
  - Destruction is easy; Building is hard
- Biology fights entropy increase: multigenerational
  - Life is about paying it forward $\Rightarrow$ enlightenment
  - Our children are more important than ourselves
  - Action: good; Inaction: bad (neglect, ignore)
- Robert Pirsig's evolutionary hierarchy of Quality
  1. Intellectual (least entropy, maximum information)
  2. Social
  3. Biological
  4. Physical (most entropy, minimum information)
- Applications: health, mutual care, free speech

Curtin University

Physics-Biology tension

- Physics: Entropy increases, information decreases
  - Destruction is easy; Building is hard
- Biology fights entropy increase: multigenerational
  - Life is about paying it forward $\Rightarrow$ enlightenment
  - Our children are more important than ourselves
  - Action: good; Inaction: bad (neglect, ignore)
- Robert Pirsig's evolutionary hierarchy of Quality
  1. Intellectual (least entropy, maximum information)
  2. Social
  3. Biological
  4. Physical (most entropy, minimum information)
- Applications: health, mutual care, free speech

Curtin University

Equilibrium: stable or unstable

- In Physics, two kinds of equilibrium:
  - Stable: a small perturbation leads to restoration
  - Unstable: a small perturbation leads to collapse
- Adversarial systems are based on unstable equilibrium: Law, Politics, destructive competition
  - National Rifle Association: “The only thing that stops a bad guy with a gun is a good guy with a gun”
  - Mutually Assured Destruction (MAD) of Cold War
  - Prone to the ladder of escalation
- Cooperative (good-will) systems are based on stable equilibrium: Physics, constructive competition
  - Transition from unstable to stable equilibrium adiabatically

Curtin University

Equilibrium: stable or unstable

- In Physics, two kinds of equilibrium:
  - Stable: a small perturbation leads to restoration
  - Unstable: a small perturbation leads to collapse
- Adversarial systems are based on unstable equilibrium: Law, Politics, destructive competition
  - National Rifle Association: “The only thing that stops a bad guy with a gun is a good guy with a gun”
  - Mutually Assured Destruction (MAD) of Cold War
  - Prone to the ladder of escalation
- Cooperative (good-will) systems are based on stable equilibrium: Physics, constructive competition
  - Transition from unstable to stable equilibrium adiabatically

Curtin University

Equilibrium: stable or unstable

- In Physics, two kinds of equilibrium:
  - Stable: a small perturbation leads to restoration
  - Unstable: a small perturbation leads to collapse
- Adversarial systems are based on unstable equilibrium: Law, Politics, destructive competition
  - National Rifle Association: “The only thing that stops a bad guy with a gun is a good guy with a gun”
  - Mutually Assured Destruction (MAD) of Cold War
  - Prone to the ladder of escalation
- Cooperative (good-will) systems are based on stable equilibrium: Physics, constructive competition
  - Transition from unstable to stable equilibrium adiabatically

Curtin University

Individual-Society balance

- Physics problems: one-body, two-body, three-body, few-body, many-body, statistical
- Self-interest: individuals are one-body problems
- Societal-interest: individuals are statistical problems
  - Population movement: treat as an ideal gas

$$PV = k_B NT$$

- Societies/organisations:
  - Individualistic: “Look after #1”
  - Totalitarian: “Some of you may die, but it is a sacrifice I’m willing to make!”
  - Balanced: “All for one, one for all!”

Curtin University

Individual-Society balance

- Physics problems: one-body, two-body, three-body, few-body, many-body, statistical
- Self-interest: individuals are one-body problems
- Societal-interest: individuals are statistical problems
  - Population movement: treat as an ideal gas

$$PV = k_B NT$$

- Societies/organisations:
  - Individualistic: “Look after #1”
  - Totalitarian: “Some of you may die, but it is a sacrifice I’m willing to make!”
  - Balanced: “All for one, one for all!”

Curtin University

Individual-Society balance

- Physics problems: one-body, two-body, three-body, few-body, many-body, statistical
- Self-interest: individuals are one-body problems
- Societal-interest: individuals are statistical problems
  - Population movement: treat as an ideal gas

$$PV = k_{\mathrm{B}} NT$$

- Societies/organisations:
  - Individualistic: “Look after #1”
  - Totalitarian: “Some of you may die, but it is a sacrifice I’m willing to make!”
  - Balanced: “All for one, one for all!”

Curtin University

Individual-Society balance

- Physics problems: one-body, two-body, three-body, few-body, many-body, statistical
- Self-interest: individuals are one-body problems
- Societal-interest: individuals are statistical problems
  - Population movement: treat as an ideal gas

$$PV = k_{\mathrm{B}} NT$$

- Societies/organisations:
  - Individualistic: “Look after #1”
  - Totalitarian: “Some of you may die, but it is a sacrifice I’m willing to make!”
  - Balanced: “All for one, one for all!”

Curtin University

Individual-Society balance

- Physics problems: one-body, two-body, three-body, few-body, many-body, statistical
- Self-interest: individuals are one-body problems
- Societal-interest: individuals are statistical problems
  - Population movement: treat as an ideal gas

$$PV = k_{\mathrm{B}} NT$$

- Societies/organisations:
  - Individualistic: “Look after #1”
  - Totalitarian: “Some of you may die, but it is a sacrifice I’m willing to make!”
  - Balanced: “All for one, one for all!”

Curtin University

Individual-Society balance

- Physics problems: one-body, two-body, three-body, few-body, many-body, statistical
- Self-interest: individuals are one-body problems
- Societal-interest: individuals are statistical problems
  - Population movement: treat as an ideal gas

$$PV = k_{\mathrm{B}} NT$$

- Societies/organisations:
  - Individualistic: “Look after #1”
  - Totalitarian: “Some of you may die, but it is a sacrifice I’m willing to make!”
  - Balanced: “All for one, one for all!”

Curtin University

Physics culture good for Life

Einstein:

- "Things should be made as simple as possible, but not simpler". Too simple: misuse of
  - Collective nouns (gender, religion, nationality)
  - Metrics (ATAR, money, university rankings)
- "There are things that count which cannot be counted, and there are things that can be counted which do not count".
  - Quality cannot be counted, requires right culture
  - "Culture eats strategy for breakfast"
  - Good culture: individual action benefits all

Curtin University

Physics culture good for Life

Einstein:

- "Things should be made as simple as possible, but not simpler". Too simple: misuse of
  - Collective nouns (gender, religion, nationality)
  - Metrics (ATAR, money, university rankings)
- "There are things that count which cannot be counted, and there are things that can be counted which do not count".
  - Quality cannot be counted, requires right culture
  - "Culture eats strategy for breakfast"
  - Good culture: individual action benefits all

Curtin University

Physics culture good for Life

- Evidence-based, derivable, falsifiable
  - Humanities: “You are not entitled to any opinion, only what you can argue for”
  - Understands correlation-causality dilemmas
- Progress: teamwork with “responsible leadership”
  - “champion team will beat a team of champions”
  - balance of autonomy, mastery and purpose
  - is incremental, rarely revolutionary
- Unifies: concentrates on message not messenger
- Communication: a balance of clarity and brevity
- Conflicts, personal/organisational, are opportunities
- If a solution exists, Physics will find it!

Curtin University

Physics culture good for Life

- Evidence-based, derivable, falsifiable
  - Humanities: “You are not entitled to any opinion, only what you can argue for”
  - Understands correlation-causality dilemmas
- Progress: teamwork with “responsible leadership”
  - “champion team will beat a team of champions”
  - balance of autonomy, mastery and purpose
  - is incremental, rarely revolutionary
- Unifies: concentrates on message not messenger
- Communication: a balance of clarity and brevity
- Conflicts, personal/organisational, are opportunities
- If a solution exists, Physics will find it!

Curtin University

Physics culture good for Life

- Evidence-based, derivable, falsifiable
  - Humanities: “You are not entitled to any opinion, only what you can argue for”
  - Understands correlation-causality dilemmas
- Progress: teamwork with “responsible leadership”
  - “champion team will beat a team of champions”
  - balance of autonomy, mastery and purpose
  - is incremental, rarely revolutionary
- Unifies: concentrates on message not messenger
- Communication: a balance of clarity and brevity
- Conflicts, personal/organisational, are opportunities
- If a solution exists, Physics will find it!

Curtin University

Physics culture good for Life

- Evidence-based, derivable, falsifiable
  - Humanities: “You are not entitled to any opinion, only what you can argue for”
  - Understands correlation-causality dilemmas
- Progress: teamwork with “responsible leadership”
  - “champion team will beat a team of champions”
  - balance of autonomy, mastery and purpose
  - is incremental, rarely revolutionary
- Unifies: concentrates on message not messenger
- Communication: a balance of clarity and brevity
- Conflicts, personal/organisational, are opportunities
- If a solution exists, Physics will find it!

Curtin University

Physics culture good for Life

- Evidence-based, derivable, falsifiable
  - Humanities: “You are not entitled to any opinion, only what you can argue for”
  - Understands correlation-causality dilemmas
- Progress: teamwork with “responsible leadership”
  - “champion team will beat a team of champions”
  - balance of autonomy, mastery and purpose
  - is incremental, rarely revolutionary
- Unifies: concentrates on message not messenger
- Communication: a balance of clarity and brevity
- Conflicts, personal/organisational, are opportunities
- If a solution exists, Physics will find it!

Curtin University

Physics culture good for Life

- Evidence-based, derivable, falsifiable
  - Humanities: “You are not entitled to any opinion, only what you can argue for”
  - Understands correlation-causality dilemmas
- Progress: teamwork with “responsible leadership”
  - “champion team will beat a team of champions”
  - balance of autonomy, mastery and purpose
  - is incremental, rarely revolutionary
- Unifies: concentrates on message not messenger
- Communication: a balance of clarity and brevity
- Conflicts, personal/organisational, are opportunities
- If a solution exists, Physics will find it!

Curtin University

Questions and Discussion

Physics of Life, Universe and Everything

Thank you!