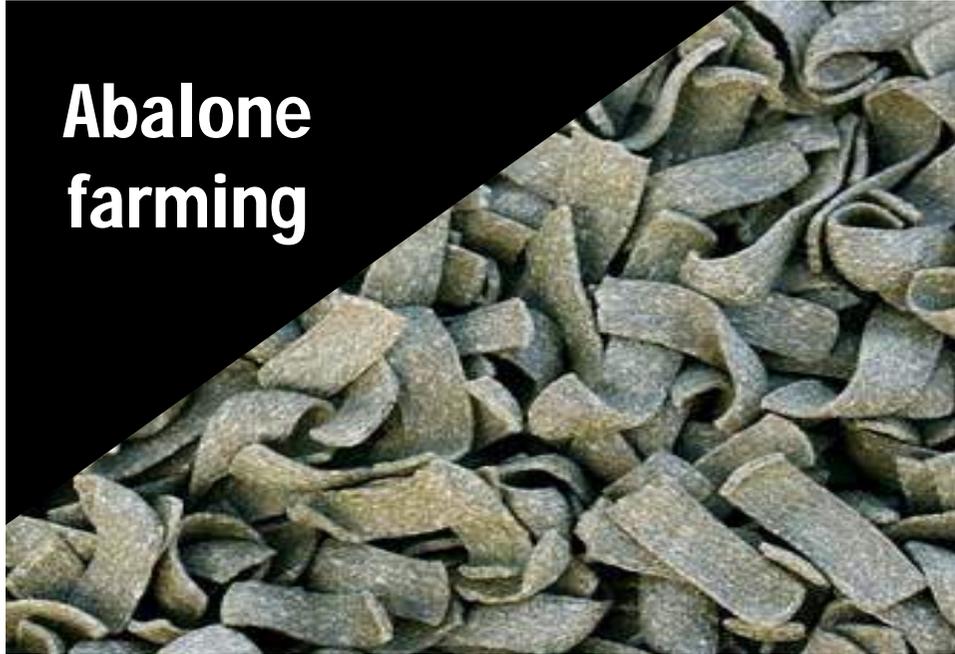


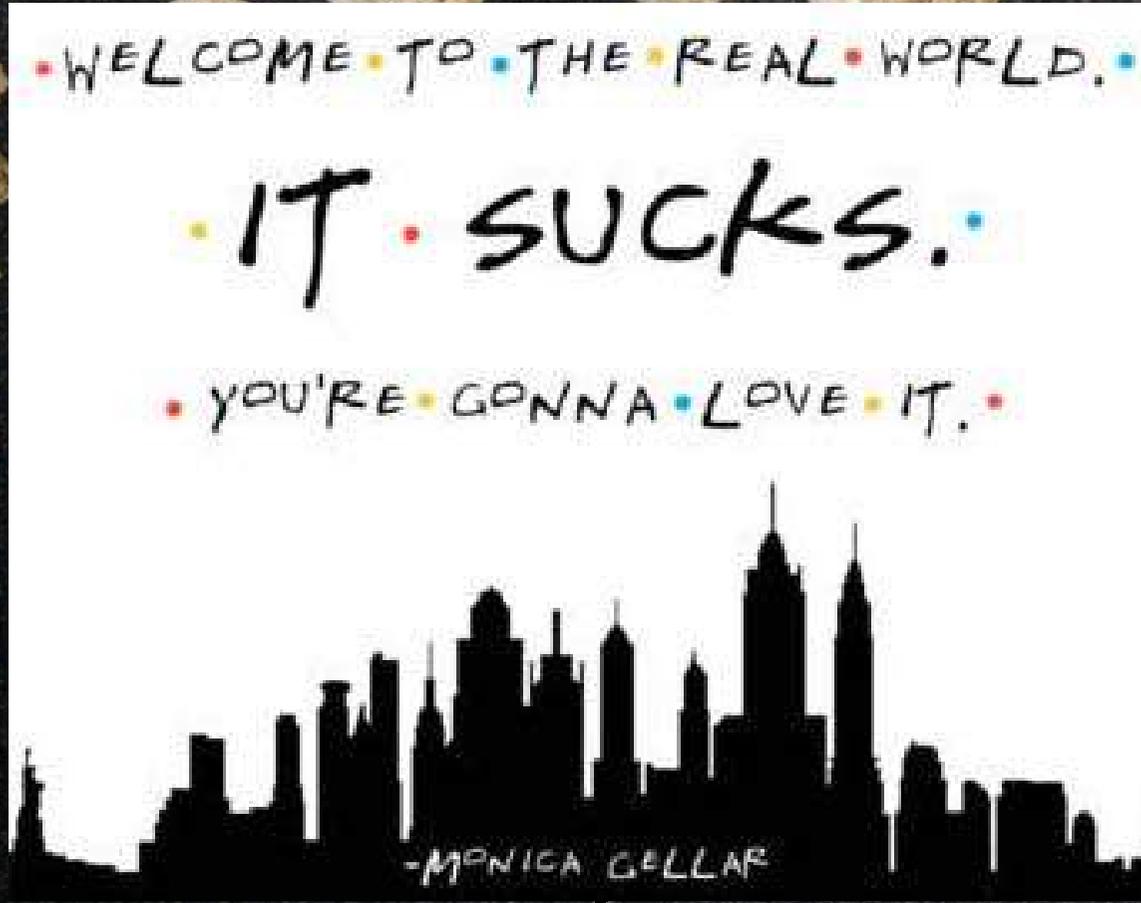
Abalone farming



Husbandry conditions such as: water temperature, stocking densities, ammonia and oxygen saturation levels, the handling and transportation of animals and their dietary needs are controlled within narrow parameters.



Abalone farming



Slow and variable abalone growth is a real life problem that abalone farmers currently face. Shortening this growth duration and elimination of these growth variances could reduce production costs and increase turnover in the long run.

Growth variation



SASHIMI ABALONE

Elucidating those factors that play a role in growth variability is urgently needed.

The high commercial value of abalone ensures that research on various aspects of their biology remains relevant.



CANNED ABALONE



DRIED ABALONE

Inter-individual variation ~ unexplained variance, receiving less research attention.

Inter-individual variation: Differences in growth rates shown by different individuals under identical environmental conditions.

Growth = irreversible increase in mass of an organism.
Can be investigated by looking at metabolism.

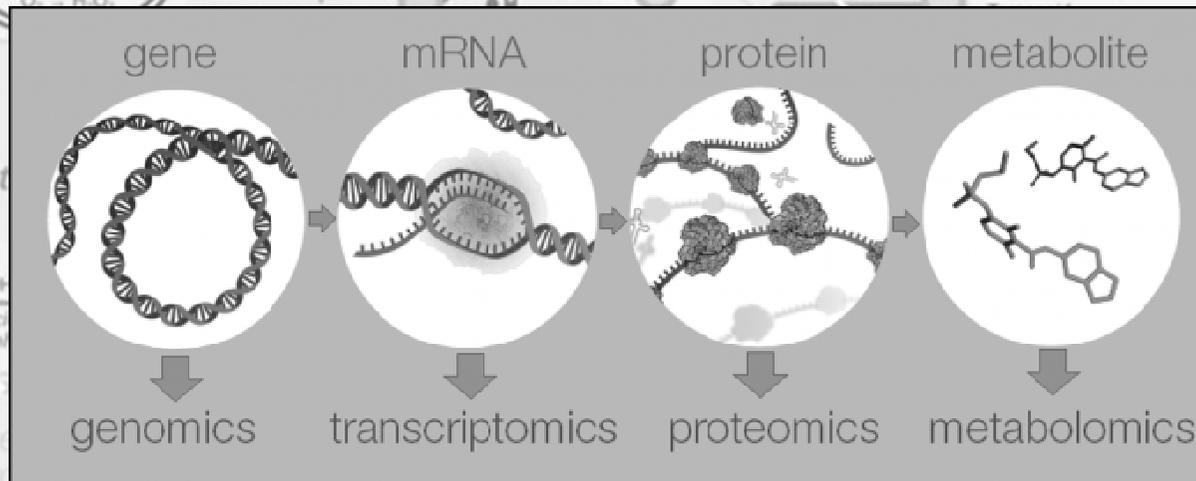


LIVE ABALONE

Focus on metabolism

Metabolomics

Non-biased identification and quantification of metabolites in a biological system using highly selective and sensitive analytical techniques and analysed using biostatistics.



Metabolites

Metabolome

Functional state of cells

Direct signature of biochemical activity

Metabolomics

"Metabolites, after all, are the ultimate molecular arbiters of biological function..." - Jeffrey Perkel (2012) *The Scientist*

Metabolomics at the NWU

Human Metabolomics

Drives metabolomics research and commercial services at the North-West University (NWU), Potchefstroom Campus, South Africa.

Sufficient infrastructure

Experienced laboratory personnel

Analytical platform specialists

(Bio) Statisticians



GC-TOF



NMR



LC-QTOF



LC-Ion trap



LC-QQQ



GC-MSD



GCxGC-TOF



HPLC



LC-IM-QTOF

Metabolomics and abalone

Natural stress



Diet

Hypoxic stress



Thermal stress

Starvation

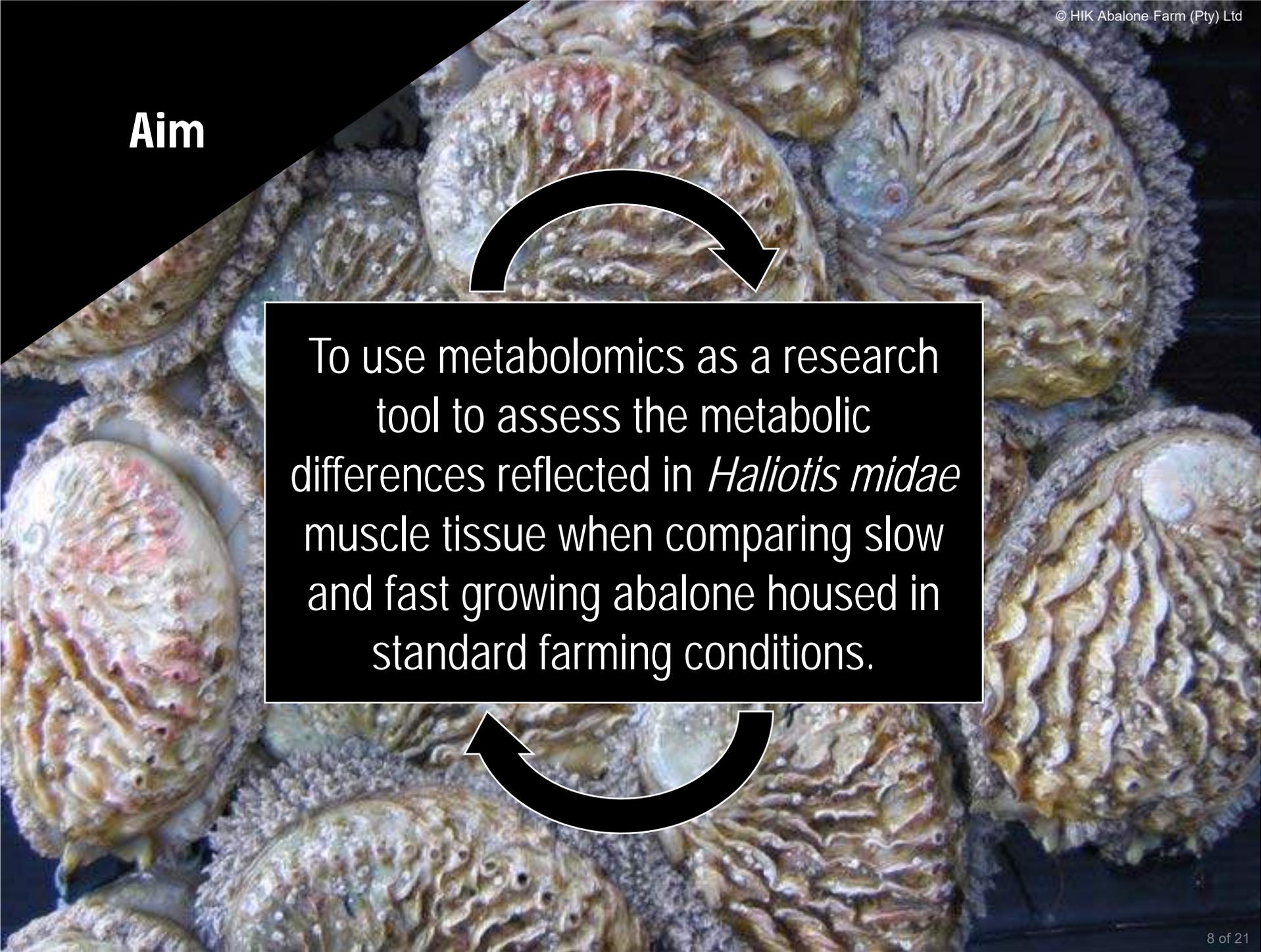


© HIK Abalone Farm (Pty) Ltd

Growth?



Aim



To use metabolomics as a research tool to assess the metabolic differences reflected in *Haliotis midae* muscle tissue when comparing slow and fast growing abalone housed in standard farming conditions.

Experimental design

Abalone growth and size grading were monitored for 8 months.

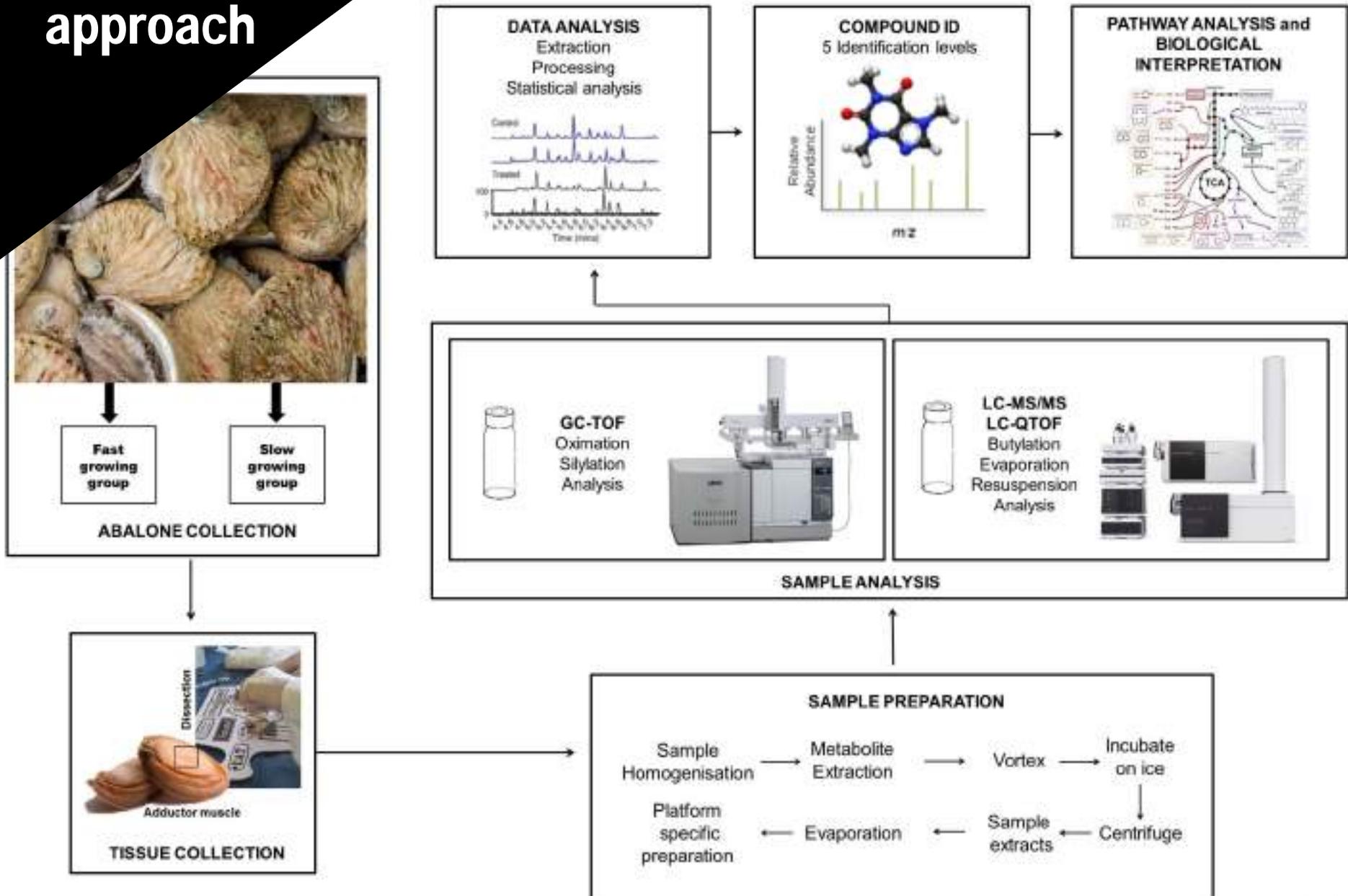


Slow growing group
Visibly smaller than other abalone in the same sampling basket at an identical life stage.



Fast growing group
Visibly larger than other abalone in the same sampling basket at an identical life stage.

Experimental approach

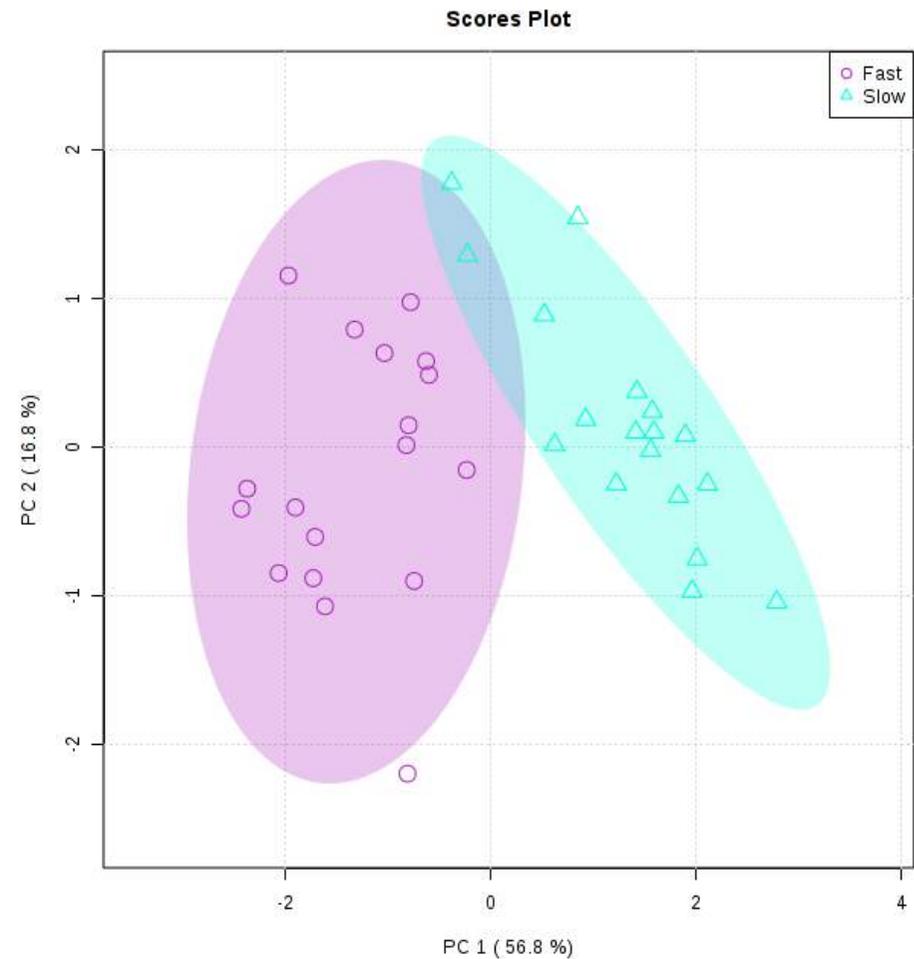


Results

Univariate analysis

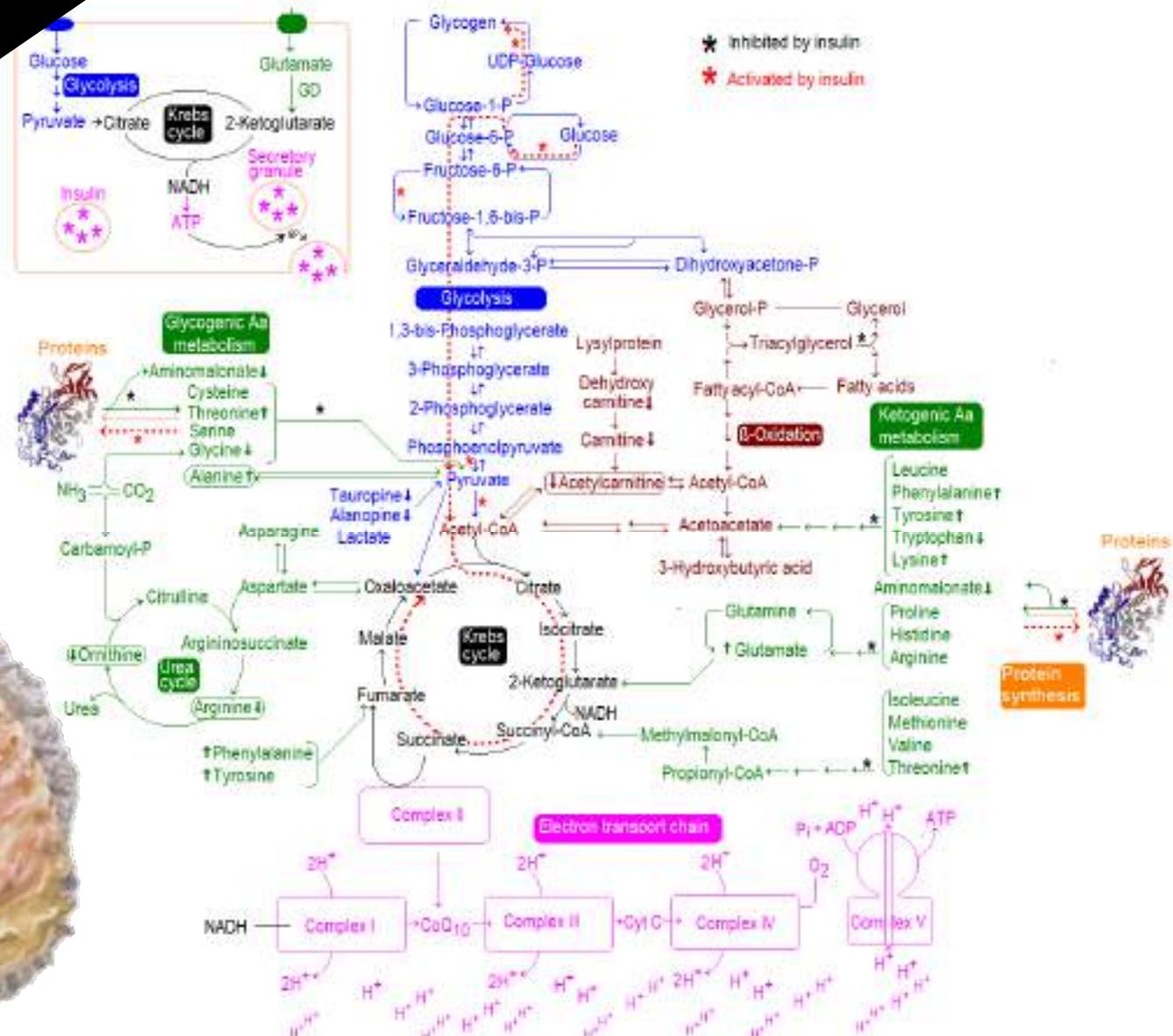
Compound	Fast growers	p-value <0.05	d-value >0.8
Glycine	↓	1.69E-14	3.07
Glutamate	↑	1.49E-12	3.27
N,N-dimethylglycine	↓	3.18E-12	2.87
Carnitine	↓	4.20E-10	2.29
Phenylalanine	↑	5.03E-09	2.21
Lysine	↑	8.61E-08	1.86
Tauropine	↓	1.54E-07	1.63
Arginine	↓	3.90E-06	1.61
Aminobenzoate	↓	5.16E-06	1.31
Picolinate	↓	4.16E-05	1.37
Dehydroxycarnitine	↓	1.43E-04	1.22
Ornithine	↓	1.67E-04	1.39
Alanine	↑	3.62E-04	1.22
Aminomalonate	↓	5.63E-04	1.15
Acetylcarnitine	↓	6.14E-04	0.92
Tryptophan	↓	9.63E-04	1.01
Threonine	↑	3.73E-03	0.92
Alanopine	↓	4.41E-03	0.80
Tyrosine	↑	6.14E-03	0.80

Multivariate analysis



Principal component analysis of slow and fast growing abalone.

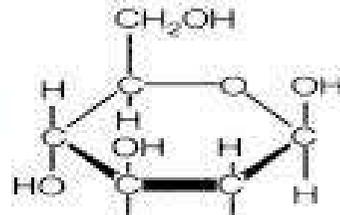
Metabolite profile - fast growth



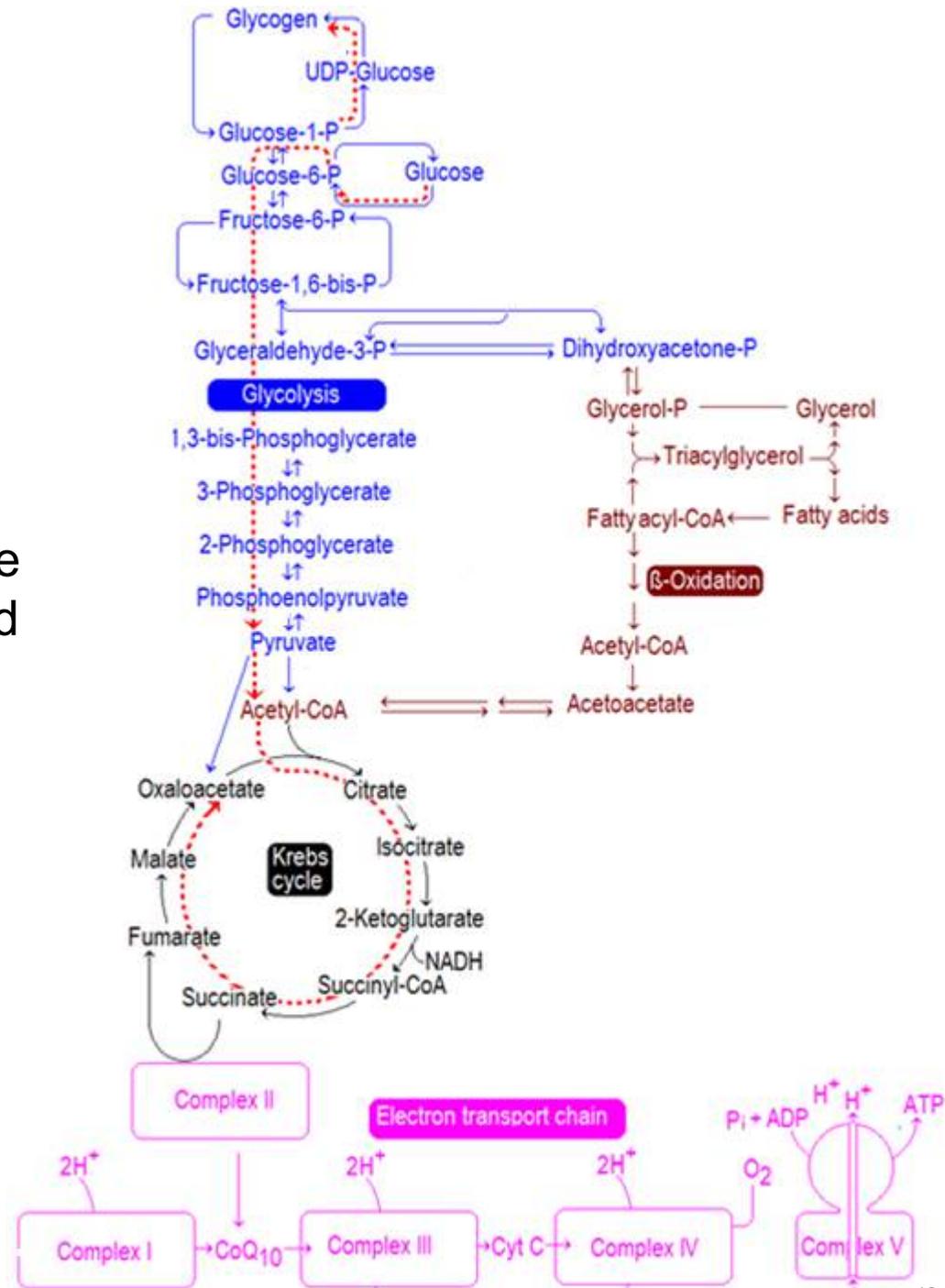
Metabolite profile of fast growing *H. midae*. The metabolites affected throughout carbohydrate (blue), amino acid (green) and fatty acid (brown) metabolic pathways are indicated by an increase (↑) or decrease (↓) in metabolite abundance as compared to the slow growing abalone group.

Carbohydrate metabolism

Sufficient carbohydrate sources were available to ensure adequate energy production during standard farming conditions.

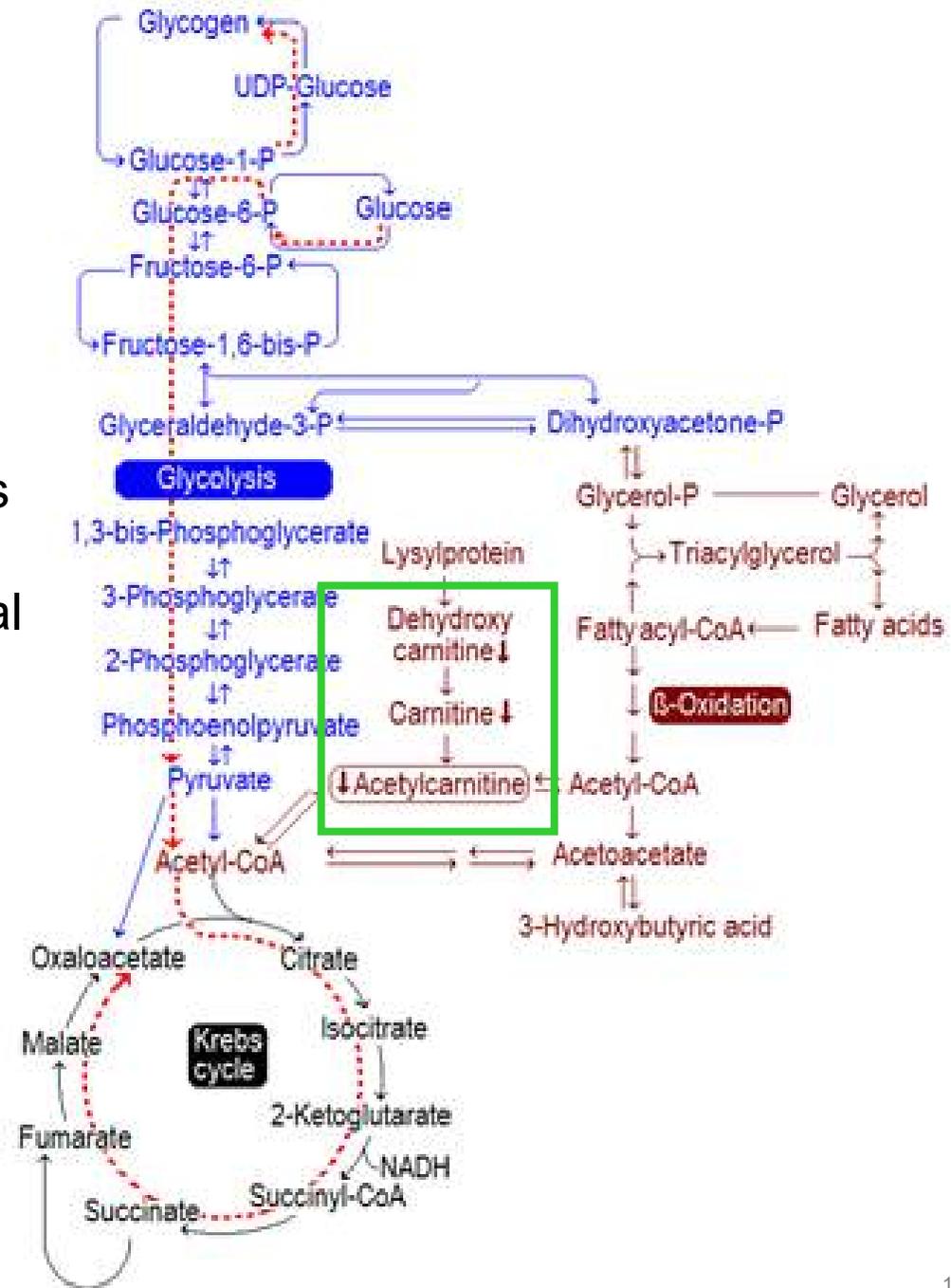


CARBOHYDRATES



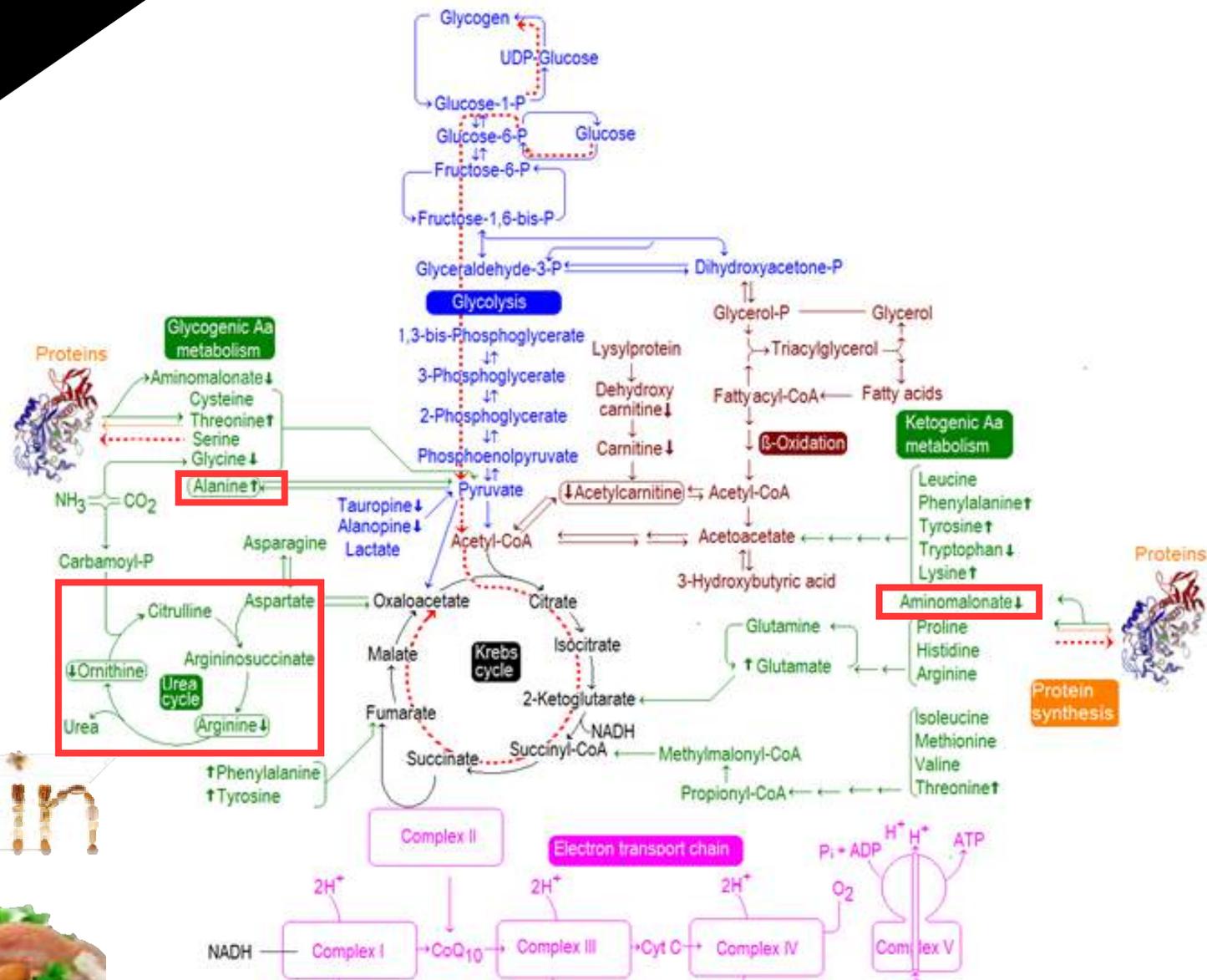
Fatty acid carnitine metabolism

Fast growing abalone require less energy via catabolism of fatty acids. Thus sufficient mitochondrial activity is present.



Protein (amino acid) metabolism

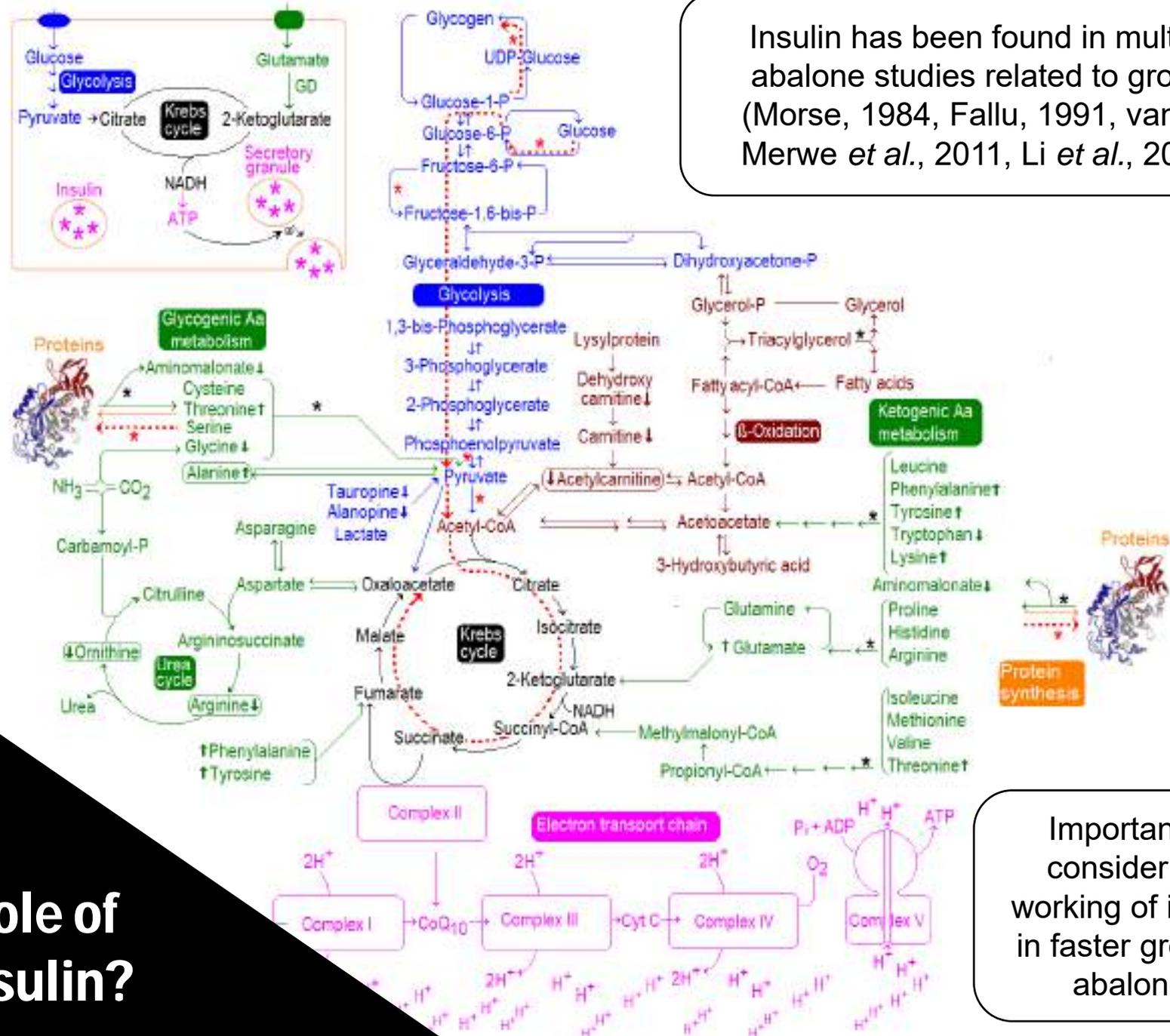
Elevated protein synthesis is suggested in the fast growing abalone group.



Protein



Insulin has been found in multiple abalone studies related to growth (Morse, 1984, Fallu, 1991, van der Merwe *et al.*, 2011, Li *et al.*, 2012).

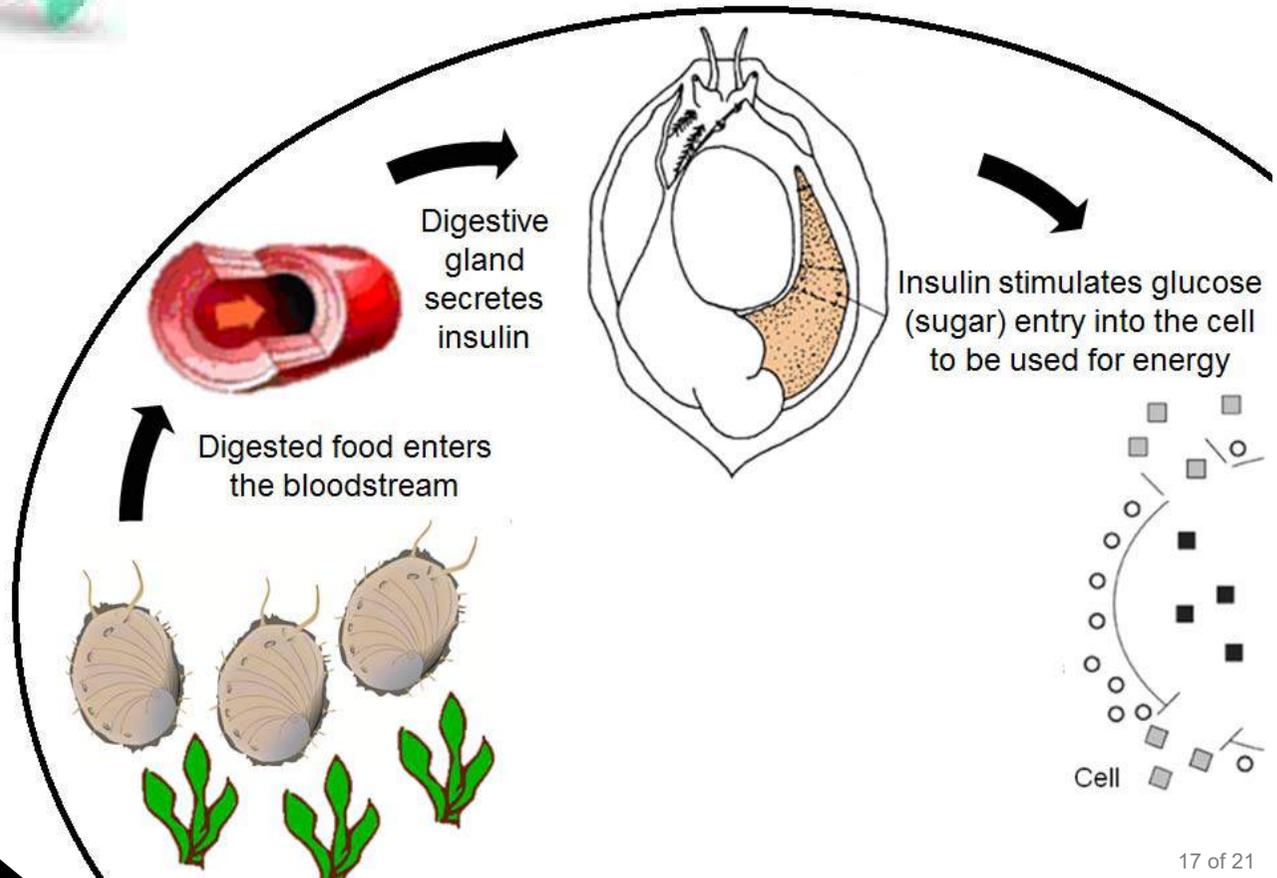


Role of insulin?

Important to consider the working of insulin in faster growing abalone.

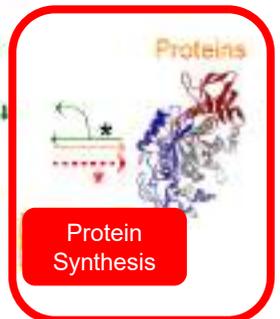
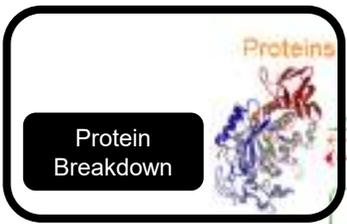
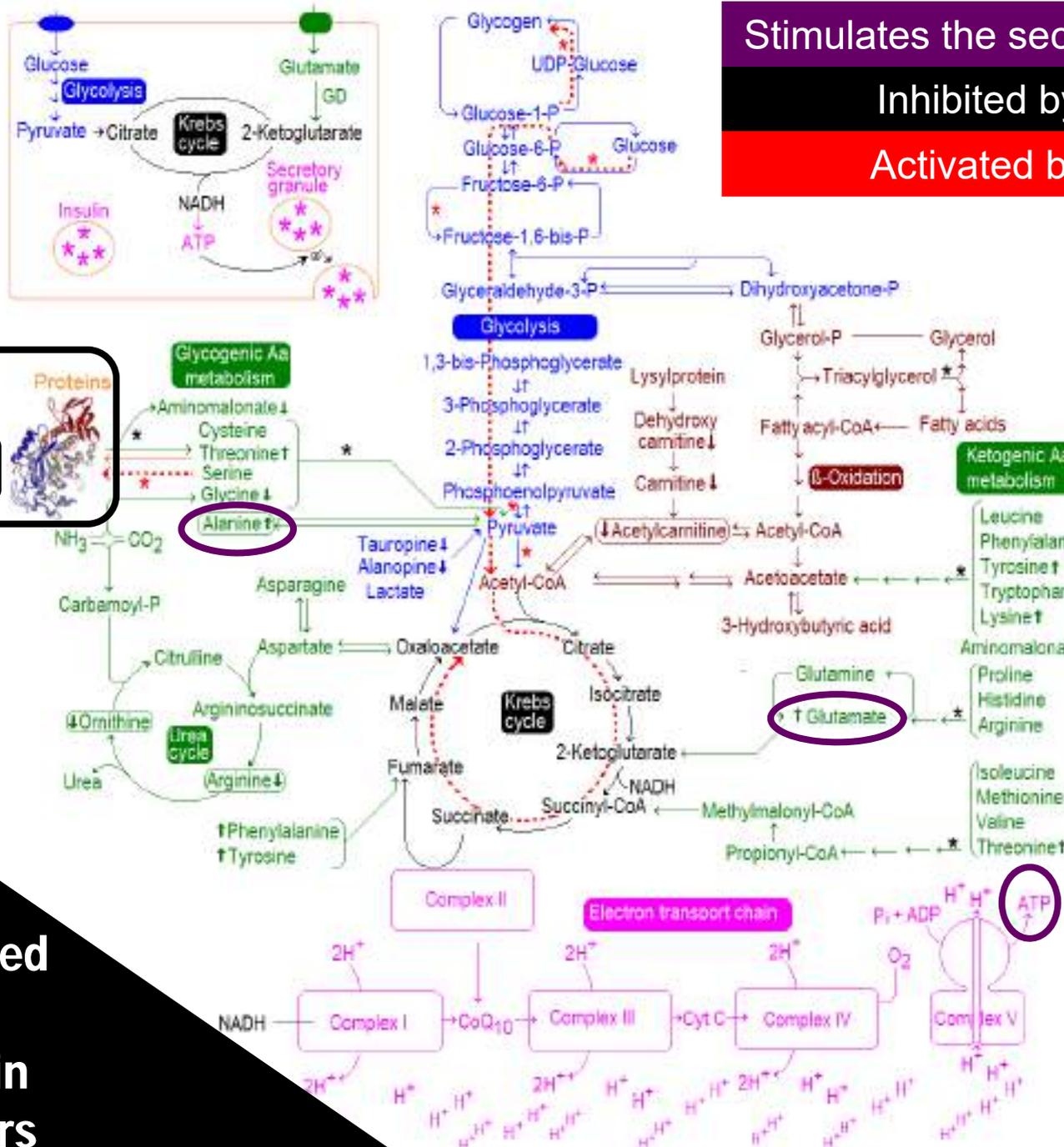


Insulin: peptide hormone, considered to be the body's main anabolic hormone.



Insulin

Stimulates the secretion of insulin
 Inhibited by insulin
 Activated by insulin



Hypothesised working of insulin in fast growers

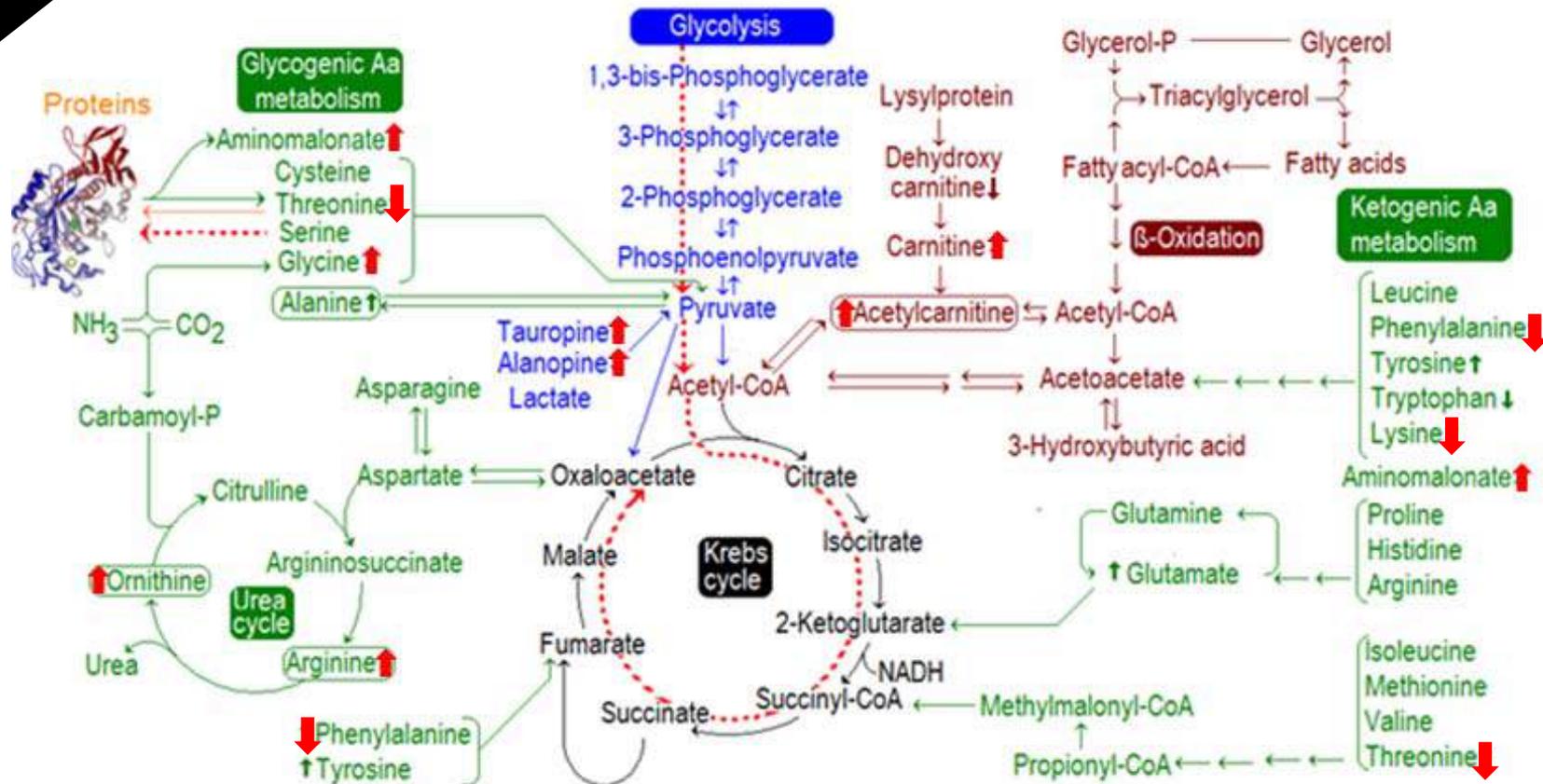
Metabolite profile - slow growth



Uncovering the metabolic response of abalone (*Haliotis midae*) to environmental hypoxia through metabolomics

Leonie Venter¹ · Du Toit Loots¹ · Lodewyk Japie Mienie¹ · Peet J. Jansen van Rensburg¹ · Shayne Mason¹ · Andre Vosloo² · Jeremie Zander Lindeque¹

Received: 17 November 2017 / Accepted: 3 March 2018
 © Springer Science+Business Media, LLC, part of Springer Nature 2018



Resultantly the slow growing abalone mimic the metabolite profile of stressed abalone, where amino acids are not purely used for anabolic activity (the desired farming outcome), but is used in catabolic pathways related to energy production.

Conclusion

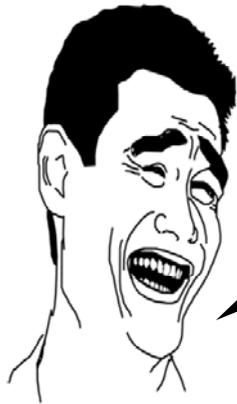
Amino and fatty acids → anabolic pathways → ↑ muscle mass.

Use central metabolism for energy during standard farming conditions.

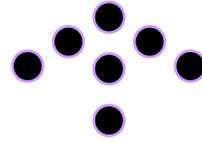
Slow growing abalone ~ protein catabolism. Energy allocation for breakdown of metabolic products has priority over abalone growth.

Metabolomics is valuable for investigating metabolic growth processes.

Faster growing abalone: use insulin + amino acids to enhance protein synthesis → ↑ muscle proteins and larger abalone.



NOTHING...
I'M
GRADUATING!



Alternative
sampling
time

Assess older and younger animals
to determine when metabolic
changes are the most prominent.

Stable
isotope
labelling

Understanding of metabolic flux
in known and unknown pathways.

Test
hypothesis

Insulin primarily responsible for protein
synthesis in faster growing individuals.

**Future
work**

Why do some individuals utilise amino acid reserves more rapidly for protein synthesis?

VENTER, L., VOSLOO, A., LOOTS, D. T., MIENIE, L.J., JANSEN VAN RENSBURG, P. J. & LINDEQUE, J. Z.
2018. Characterising the metabolic differences related to growth variation in farmed *Haliotis midae*.
Aquaculture, <https://doi.org/10.1016/j.aquaculture.2018.04.052>

Thank you, Dankie, Ke a leboga



Hermanus, South Africa



UNIVERSITY OF
KWAZULU-NATAL™
INYUVESI
YAKWAZULU-NATALI



